ARMS CONTROL, DISARMAMENT, AND NATIONAL SECURITY

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5. The Arms Race and Some of Its Hazards

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PREFACE

IT IS EASY TO WRITE GRAPHICALLY AND PERSUASIVELY OF THE DANGERS of the arms race, nuclear and otherwise. Such documents are often well received: the author's heart seems to be in the right place; he is for people and against the abominations science and technology have produced. Yet, this question remains unanswered: Why do nations in general, our own in particular, continue to play such a dangerous and pointless game?

Here we hit on the nub of the matter: the game is indeed dangerous, but not pointless, since not to play it (even to reduce forces or submit to arms control) can also be dangerous: a Pearl Harbor or a Munich is all too possible. If we examine the whole range of possibilities, beginning with unilateral disarmament, surrender, appeasement, or accommodation, and ending with an accelerated arms race, preventive war, Mutual Homicide Pacts, and Doomsday Machines, we discover that there are no pleasant, safe, or even unambiguously moral positions for the individual, for a nation, or for civilization. Unfortunately, the discussions that concentrate on one facet of our dangerous future tend to create a psychological atmosphere conducive to the neglect of the remaining problems of security. This is no reason for not discussing the dangers of the arms race (or any other dangers), but only for emphasizing the ultimate need for a balanced comparison of all the dangers.

I have written elsewhere * on why adequate arms control may be essential if we are to reach 1975 and later years without a major thermonuclear war, while emphasizing that we may also need military establishments of a much higher quality than is usually conceded, even by people who think of themselves as "militarists," and the many difficulties and dangers of arms control. I will not summarize the arguments here. I would only be doing myself a disservice if I did so. This is a difficult, unpleasant, and emotional

* This chapter is based in part on my book, *On Thermonuclear War* (Princeton, N.J.: Princeton University Press, December 1960).

subject; the points raised are often irritating or dismaying, and many readers transfer their irritation and dismay to the author. For example, if one presents a balanced account of the risks an attacker might face from a retaliatory blow, it is easy to show that, subject to some chilling uncertainties, there are many circumstances in which the risks the attacker faces are considerably less than is generally believed. As a result, there are plausible situations in which a perfectly sane (but calculating, decisive, or ruthless) attacker might decide that "it is less risky to go to war than to live with the current situation or crisis." At this point, many readers conclude that the analyst is advocating preventive war; in other words, instead of examining the arithmetic, they conclude that anyone who calculates this way wants to act this way.

While the most important problems of the 1960's and 1970's may result from the arms race itself, rather than from the political and military dangers against which the arms race is supposed to protect us, those dangers exist. Today they are manageable only because the arms protect us from them; *ill-advised* measures to control the arms race can still reduce our security.* We are trying to negotiate some very rough and dangerous terrain. While it is by no means clear that there are any "reasonable" routes to wherever we want to go, it is clear that there are precipitous and unscalable heights in all directions. Let us now examine some of this terrain.

VARIOUS WAYS IN WHICH WAR CAN START

The major danger of the arms race lies precisely in the fact that the arms may be used; thermonuclear war may be unthinkable, but it is not impossible. Arms control can reduce the risks that ensue from the ever-present possibility of war by reducing:

1. The number of events, both international (tensions and crises) and technical (false alarms and misunderstandings), that could give rise to war.
2. The probability that an event of the kind that could cause war will actually result in war.
3. The damage of an actual war, not only by abolishing the use of certain weapons and controlling the use of others, but also by facilitating ahead of time the machinery by which wars are ended before they become overwhelmingly destructive.

There is no space here to expand on these possibilities; they are all discussed elsewhere in this book. However, it may be well now to discuss systematically how a war could arise and indicate some of the problems to be considered. I will begin by listing a number of possibilities, in a semi-technical jargon intended to categorize and describe them.

1. *Unpremeditated war* (human or mechanical error, false alarm, self-fulfilling prophecy, unauthorized behavior).

* The possibility implied by the author's use of the word *still* in this sentence is to be noted.—ED.

2. *Miscalculation* (game of "Chicken," rationality of irrationality strategies, escalation, overconfidence).

3. *Calculation* (Type II Deterrence situation; preventive war; pre-emptive war; world domination; solution to a desperate crisis).

4. *Catalytic war* (ambitious third nation; desperate third nation).

The items in these four categories are neither exhaustive nor distinct from one another. They are not exhaustive because our weapon systems are so new, and their impact, both on one another and on international relations, is so little known that it would not be surprising if a war started in some manner not heretofore thought of. However, I have made the list as exhaustive as possible; in doing so it has been convenient to list categories that occasionally overlap. This is probably better than to strain too much to prevent duplication or leave out some important possibility.

Unpremeditated War. The four categories are ordered by the writer's personal estimate of their likelihood of actually being a cause of war in the next decade or two. I have put unpremeditated war at the top of the list, the fearful possibility that a war may occur almost unintentionally. There is a widespread fear that this could occur; that a button may be pressed accidentally, an electrical circuit short, a relay stick, a telephone call or other message be misunderstood, an aurora borealis or meteor or flock of geese be mistaken for an attack, a switch fail, some ICBM's launched through some mechanical or human error, some stockpile weapons accidentally exploded, and so on. Such things have happened in the past and may happen again. However, unless one side or the other is careless enough to install a quick-reacting, nonrecallable strategic system, it is most unlikely that any single one of the above events would trigger off a retaliatory attack. It is just because radars do indeed occasionally give false alarms and accidents do happen that it is essential for both sides to install weapon systems that either have so-called "fail safe" or "positive control" features built into them, or that are large enough and well enough protected that they do not need to be "trigger happy" to survive. If a system can accept the enemy's attack and still strike back effectively, the decision maker has time to evaluate and decide—time to be careful. Such systems may use an ambiguous warning so as to take some temporizing measure that will reduce vulnerability to enemy attack or provide a better posture from which to retaliate. But the commander can then wait for further confirmation before making any irrevocable commitments.

There is a danger that the temporizing measures that are instituted on an ambiguous warning will remove some of the psychological, legal, and physical safeties that normally govern the strategic force, so that there is a greater load thrown on the remaining safeguards. For this reason several accidents in a row or even a simple accident during a period of considerable tension could be dangerous. Actually, the greatest danger is the possibility that a chain of "self-fulfilling prophecies" is set into motion. It is perfectly conceivable for one side's temporizing action to be observed by the other

side and to be misinterpreted as being aggressive rather than defensive, thus causing the other side also to make some temporizing defensive move. This second defensive move can in turn be misread by the side originally alerted as confirming his suspicions, so he may make some further moves. It is then possible for reactions and signals to be set into motion which trigger off further reactions and signals by both sides until a point of no return is reached. This is one reason that it is necessary for each side not only to be cautious and responsible, but also to make sure that the other side also understands what is happening. In so far as any temporizing measures depend on doing things which raise apprehensions on the other side, it is important to be prepared to allay those apprehensions. This is possibly a very fruitful area for arms control.

The Soviets are completely aware of the problem. For example, in a Security Council debate of April 21, 1958, Arkady S. Sobolev made the following statement:

> American generals refer to the fact that up to the present time the American planes have taken off on their flights and returned to their bases as soon as it became clear that it was a case of false alarm. But what would happen if American military personnel observing their radar screens are not able in time to determine that a flying meteor is not a guided missile and that a flight of geese is not a flight of bombers? Then the American planes will continue their flight and will approach the borders of the Soviet Union.
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> But in such a case the need to insure the security of the Soviet people would require the USSR to make immediate retaliatory measures to eliminate the oncoming threat. The Soviet Government would like to hope that matters will not go so far.
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> In order to get a clearer idea of the extremely dangerous character of acts of the United States [that are] dangerous to peace, it is enough to ask the question what would happen if the military Air Force of the Soviet Union began to act in the same way as the American Air Force is now acting? After all, Soviet radar screens also show from time to time blips which are caused by the flight of meteors or electronic interference. If in such cases Soviet aircraft also flew out carrying atom and hydrogen bombs in the direction of the United States and its bases in other states, what situation would arise?
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> The air fleets of both sides, having observed each other, having discerned each other somewhere over the Arctic wastes or in some other place, apparently would draw the conclusion natural under those circumstances, that a real enemy attack was taking place. Then the world would inevitably be plunged into the hurricane of atomic war.[1]

In spite of their awareness of the problem, the Soviets have tended to emphasize disarmament almost, but not quite, to the exclusion of other aspects of arms control. For example, at the 1958 Surprise Attack Conference, they stressed larger issues and refused to discuss narrow technical issues although our own position may have been excessively narrow. To this writer it seems dangerous to wait for a settlement of the political issues

before considering this problem, but in this kind of a problem it takes two to make an agreement. However, even informal implicit agreements or, on some aspects, unilateral concessions can be helpful.

It is also conceivable that some pathological or irresponsible person will deliberately try to start a war or crisis. The Soviets have made much of the possibility that a deranged or irresponsible American pilot on airborne alert would take it into his head to attack Russia alone. Not only are there many safeguards against this, but it is most unlikely that a single-plane attack would touch off a war. A much more ominous possibility is given in the book *Red Alert,*[2] in which a determined SAC general, who, unknown to his superiors, is sick with an incurable ailment (and whose judgment and sense of discipline are thus affected), decides personally to end the Soviet problem once and for all. The most interesting part is the clever way he gets around the rather elaborate system set up to prevent exactly this kind of behavior.

I should make clear that I believe that, currently at least, the probability of unpremeditated war is low. The reason I put it on the top of the list is because I believe (assuming, perhaps optimistically, that both sides are careful, competent, and responsible) the other ways in which a war could occur should have an even lower probability. It is also clear that many of the methods recommended to reduce the probability of war by accident might very well result in increasing the likelihood of war from one of the other causes. After both these points are made, it must also be mentioned that nobody can estimate realistically what the probability of accidental war is. (There seems to be some tendency to underestimate the probability of war. For example, Wheeler-Bennett reports in his book, *Munich: Prologue to Tragedy,* that on January 1, 1939, Lloyds was giving 32 to 1 odds against war in 1939. This was three months after Munich and eight months before the war actually started. While it would be hard to convince me that it is as high as, say, 1 in 10 a year, still, if it were this high, the situation would be entirely unsatisfactory. Even if it were 1 in 100 a year, it would still be unsatisfactory, because the current state of affairs could not be allowed to continue indefinitely. One must eventually introduce a major change in the situation, or expect to get into a war anyway.

The really dangerous intensification in the probability of unpremeditated war is likely to come in the future, partly as a result of increased alertness or dispersal of weapons carriers in the missile age, partly as a result of the increase in the number of buttons that can be pressed accidentally, but mostly as a result of the proliferation of independent nuclear capabilities to other countries, each with its own standards of training, reliability of personnel, and safety practices.

War by Miscalculation. Nearly as worrisome as the possibility of unpremeditated war is the war which is more or less premeditated (perhaps as in the *usually uncalculated* "calculated risk")—but the decision maker doing the premeditating has miscalculated or misunderstood the risks or

consequences of his actions. Many believe that the most likely way for this to occur is as a result of the use of a committal strategy. For example, one side may make it clear that it is going to stand firm in some crisis in the belief that "since neither side wants war," the other side will back down. If the other side does not back down, then war can result. A graphic if somewhat oversimplified example of such a situation is given by Bertrand Russell:

> This sport is called "Chicken!" It is played by choosing a long straight road with a white line down the middle and starting two very fast cars towards each other from opposite ends. Each car is expected to keep the wheels of one side on the white line. As they approach each other mutual destruction becomes more and more imminent. If one of them swerves from the white line before the other, the other, as he passes, shouts "Chicken!" and the one who has swerved becomes an object of contempt.[3]

It is clear that if one side really wishes to win this game its best (rational) strategy is to commit itself irrevocably to going ahead. If one can convince the other side that one has done this, then the other side must back down. However, if the other side still refuses to back down after the irrevocable commitment has been made, it would be irrational to carry out the rationally made commitment. Since both sides will be attempting to use this strategy, it is also quite clear that the game may end in a disaster.

According to Bertrand Russell, the game is played by degenerates in America, and by nations everywhere. It is a caricature, because Russell ignores the fact that it is a major purpose of diplomacy to prevent a crisis from arising which can only be settled by the total and humiliating defeat of one side or the other. Most bargaining situations involve gains for both sides, and the major question is on the division of these gains and not the humiliation of the other side. However, the game of Chicken may occur. Barring enforceable adjudication, the less one is willing to play the game, the more likely it may be that one may end up having to play it. Life, liberty, and security may depend on being willing to play this dangerous game. As Russell states:

> Practical politicians may admit all this, but they argue that there is no alternative. If one side is unwilling to risk global war, while the other side is willing to risk it, the side which is willing to run the risk will be victorious in all negotiations and will ultimately reduce the other side to complete impotence. "Perhaps"—so the practical politician will argue—"it might be ideally wise for the sane party to yield to the insane party in view of the dreadful nature of the alternative, but, whether wise or not, no proud nation will long acquiesce in such an ignominious role. We are, therefore, faced, quite inevitably, with the choice between brinkmanship and surrender."

The game of Chicken is an extreme example of the use of "rationality of irrationality" strategies. Because these are so important it may be worth-

while to dwell on them briefly. In any bargaining situation, even the most innocuous, it can make sense to commit oneself irrevocably to do something in a certain eventuality, and at the same time it may not make sense to carry out the commitment if the eventuality occurs; if one could, one would revoke the "irrevocable" commitment. The analogy with the game of Chicken should be clear. It should also be clear that if both sides commit themselves to incompatible positions, there will be no bargain. But if the bargaining is carried on with skill, and if both sides are cautious, then the bargaining will take on the aspects of a normal commercial transaction in which both sides gain, the exact division of the gains depending on their relative skill, but in which neither is driven to the wall.

Unfortunately, in any long period of peace, there is some tendency for governments to become more and more intransigent. The thought of war may become unreal. Even more important, every government is likely to build up a background of experiences in which it did very well by standing firm and very badly when it displayed a flexible, reasonable, or conciliatory attitude. It is only when peace fails that the governments are likely to learn that standing firm on incompatible positions is not a feasible symmetrical strategy. One can almost confidently predict that unless arrangements are made for adjudication or arbitration, somebody is going to play the international analogue of Chicken once too often.

The rationality-of-irrationality war should be distinguished from one caused by the two sides having incompatible objectives which they are determined to achieve, no matter what the risks: in this case war must result. The rationality-of-irrationality war corresponds to a situation in which neither side really believes the issue is big enough to go to war over, but both sides are willing to use some partial or total strategy of commitment to force the other side to back down. As a result, they may end up in a war they would not have gone into, if either side had realized ahead of time that the other side would not back down, even under pressure.

A typical circumstance in which such a situation could arise results from the use of Type II Deterrence.* Imagine, for example, that the Soviets had done some very provocative thing, such as invading Western Europe with conventional armies, on such a large scale that we felt that we could not stop the invasion by any limited actions, and that we would not be able to rescue Europe at a later date. We might still not be willing to strike the Soviets with our SAC, in view of the terrible price we would have to pay to their retaliatory blow, even if we struck them first. However, we could evacuate our cities and place our forces on a super-alert status, and thus

* As in my book, I would like to distinguish three kinds of deterrence. Type I is the deterrence of an "all-out" direct attack. Type II is the deterrence of extremely provocative acts, other than an all-out attack on the nation using the deterrence. Type III might be called a graduated or controlled deterrence: it is the deterrence of provocations by making the potential aggressor afraid that the defender or others will then take limited actions, military or nonmilitary, which will make the aggression unprofitable.

put ourselves in a much better position to strike first and accept the retaliatory blow. We might then present the Soviets with an ultimatum. We would in effect be presenting the Russians with the following three alternatives: to initiate some kind of strike; to prolong the crisis, even though it would then be very credible that we would strike if they continued to provoke us; or to back down or compromise the crisis satisfactorily. We would hope that the Soviets would prefer the third alternative, because our Type I Deterrence would make the first choice sufficiently unattractive, and our Type II Deterrence would do the same for the second; but we might be wrong, and they might take the first alternative. Or they might take the second alternative in the assumption that we would back down, and we might not.

[Another method of getting into a war by miscalculation would be as a result of a limited move that appeared safe, but which set into motion a disastrous sequence that ended in all-out warfare. This increase is called escalation.] One can imagine some sort of crisis which gradually increased in violence or scope until it triggered one of the reactions already discussed. This could occur either because the limits of a limited war are not being observed, or because more parties are being drawn into it, or because the isues themselves become fraught with significances that did not initially exist, or because of some unauthorized or accidental behavior by subordinates. It is difficult to supply a plausible reason for escalation (except, of course, as a move in the game of Chicken), when it is to everybody's interest to control things, yet almost everyone considers that it can and perhaps will happen.

Escalation is possible particularly if one of the two contending sides does not think through the consequences of its actions. To return to the Type II Deterrence situation discussed above: it is perfectly conceivable that the Russians, looking at the 60 million hostages we have in our fifty largest cities, might decide that it was safe to attack Europe, and that we would not attack them in retaliation. They might also vaguely realize that if they attacked Europe, we would probably evacuate the 60 million hostages; but they might not understand the full consequences of that evacuation, in terms of the psychological stiffening of the backbone and the enormous decrease in the risks this country would be running if it went to war.

The possibility of escalation may actually play a useful role in deterring certain kinds of crises or limited wars. For example, it is quite clear that the nuclear-weapon systems we and the British have in Europe are on the whole fairly vulnerable to Soviet attack, so that they have little second-strike capability. Yet the Soviets might be afraid to destroy them in a limited European attack, for fear that the level of by-product destruction would automatically cause escalation into an all-out World War III. On the other hand, if the Soviets did not destroy them, the Europeans might use them, and this in turn would not only be damaging to the Soviets, but might also cause escalation into World War III. This means that lower than

all-out attacks may be deterred for fear they will escalate. The same mechanism holds, for example, if we decide to open a route to Berlin by force if the Soviets or East Germans try to close it. As of 1961, the Soviets have the capacity to apply all the counterforce they need to stop any such action. The purpose of the action is not to overwhelm Soviet countermeasures, but to make it clear to them that the stakes are large. It is clear that we might be willing to take a small but appreciable risk of an all-out war, even if we were not willing to go immediately into an all-out war. The action might be effective precisely because it was so dangerous. To the extent that various types of arms-control measures reduce the possibility of escalation, then to that extent the deterring effect of escalation on limited actions is decreased. The author finds this no reason for not carrying through such control measures, but he knows many Europeans who are antagonistic to any reliable limits on the use of violence, for the very reason that such limitations may increase the probability of a provocation at that limited level.

Another possibility of a war by miscalculation occurs when one side goes to war in the mistaken belief that it has a sufficient preponderance of force or a clever enough war plan to be able to win satisfactorily. The mistake can occur through some uncertainty being underestimated, some imponderable ignored, or sheer ignorance or recklessness. Given current beliefs in the West, it is almost impossible to imagine this happening to a Western government unless the decision makers have their judgment clouded by desperation or madness. The situation is less certain in the Communist bloc. The Chinese clearly underestimate the effects of nuclear war. Hopefully, it will be some time before they have the power to use nuclear weapons, and time may bring them greater wisdom. The Soviet estimates, as gleaned from their public statements, seem plausible, though whether this comes as a result of more or less sophistication than is prevalent in the West is hard to tell. They talk of the possibility of great destruction and suffering together with the likelihood of the "victor" surviving and recovering. The Soviets do not seem to be trigger-happy or reckless, one judges at this writing, so that it does not seem to be necessary to put much effort into attempts to educate them on the danger of being overconfident about the use of modern weapons. The Soviets may underestimate the need for collaboration in controlling the technological development and dissemination of new weapons and thus be unwilling to make the necessary compromises entailed in getting feasible arms-control programs accepted by both sides. If they go to war, however, it is as likely to be as a result of calculation as of miscalculation. This thought brings us to our next topic.

War by Calculation. War could result from calculation. After due study, a nation might decide that going to war would be the least undesirable of its choices. Common belief, of course, holds just the opposite: that war could arise only as a result of miscalculation—but this is based on the unsophisticated view that all wars result in automatic mutual annihilation.

This could happen, but in all likelihood it would not. One type of war by calculation could occur in the Type II Deterrence situation referred to above. If at that point we attacked the Soviet Union, the damage we received in return would be considerably reduced. We might well decide that our nation was better off to accept this retaliatory blow rather than let Europe be occupied, and also to accept the costs of living in the hostile and dangerous world that would result.

Or, to give another example, the Soviets suffered from 20 to 30 million casualties in World War II, and in addition they lost about one-third of their wealth. It is sometimes pointed out that this did not happen from calculation but was inflicted on a day-by-day basis: no alternatives were ever really put up to them. However, given the nature of the Nazis and their program, I would believe that even the average Soviet citizen (not to mention the government) would have been willing to accept the cost of World War II in order to achieve the position they have since won, as an alternative to Nazi domination.

Another war by calculation would be the so-called preventive war. This does not necessarily mean that one side believes the other is planning eventually to attack the first, which is therefore merely getting in the first blow. One side has only to feel that a war is inevitable—or so likely that it might as well get the disaster over with as soon as it gets a sufficient lead, so that it is safer to seize the opportunity than to wait. Such an edge is most likely to result from a technological change to which the other side has not reacted. The so-called missile gap illustrates how this problem could arise.

The United States SAC (Strategic Air Command) is supposed to be based upon about fifty home bases. If the Soviets happened to acquire, unknown to us, about three hundred missiles, then they could assign about six missiles to the destruction of each base. If the Soviet missiles had, let us say, one chance in two of completing their countdown and otherwise performing reliably, then there would only be 1 chance in 64 that any particular SAC base would survive a Soviet attack. There would be better than an even chance that all the bases would be destroyed, about one chance in three that one base would survive, and a small chance that two or more bases would survive.

A missile gap of the sort described is especially dangerous because missile attacks are so much more calculable than any other kind of attack. They are so calculable that many people feel that even a cautious Soviet planner might be willing to rely on the correctness of his estimates; that Soviet decision makers might find it the path of caution to attack while the opportunity was still available.

Actually the results of missile attacks are not mathematically predictable. There are imponderables and uncertainties with regard to such things as reliability of basic data, field degradation, intelligence leaks, and firing discipline so that the probability of something going wrong cannot be

predicted. But so many laymen and professionals persist in regarding the reliable prediction of the results of missile attacks as simple problems in engineering and physics that it would be irresponsible to rely on Soviet caution and sophistication alone as a protection. And if such an attack were successfully carried out, it would truly be a war by calculation.

The need for a quick reaction to even "hypothetical" changes in the enemy's posture is likely to persist indefinitely, in spite of the popular theory that once we get over our current difficulties we will have a so-called minimum nuclear deterrent force that will solve the Type I Deterrence problem. (Some even maintain that it will solve all strategic problems.)

It should be noted that if a serious deterrent gap ever occurred, then, even if the Soviets were not willing, either out of caution or morality, to use their superiority, the situation would still be dangerous. They might well be tempted to a strong (even reckless) foreign policy, if they believed that their military technology entitled them to some gains, or that if they got into trouble they could use their missiles to rescue themselves. This kind of situation could be especially dangerous if the Soviets considered that they could not disclose their superiority, since if they did so, we could take remedial action (e.g., an airborne alert). Still, they might be willing to hint at their superiority, in the belief that this would be just enough to make us weak or uncertain in our response in a crisis, but not move us prior to a crisis to institute the airborne alert in time.

Another possibility for preventive war could occur if an arms-control agreement broke down and one side had a considerable lead, either because of its previous success in evading detection, or its greater ability to rearm. This side might well feel that, rather than see the world subjected again to all the dangers of an arms race, it would be doing a public service to stop the race, once and for all. And this could best be done by stopping the cause of the race—its opponent. It might be especially willing to start the war soon after the arms-control agreement terminated, because the risks, even if things went awry, would not be so great at the existing low level of arms than before the arms-control agreement had lowered the absolute level of the balance of terror. The rather high probability of war breaking out after the arms race had begun again (but before both states were fully armed) is often ignored. Most writers focus attention on the situation existing at the time of the breakdown, when the posture is still determined by the agreement and on the feasible violations of the agreement, rather than on the situation some months or a year or two later.

Then there is the idea of "pre-emption," or as Einstein called it, "anticipatory retaliation." Almost all authorities agree that at present the advantages of striking first are so great that if there seems a high probability that the other side is actually attacking, it may be better to take the certain risk of a relatively small retaliatory strike rather than the high probability of a much more destructive first strike. This calculated pressure for preemption is especially likely in one situation very similar to that of "self-

fulfillment," previously discussed. Even if only one side suspects that the other may attack, each can easily become convinced that it should attack—not because it wants to, or even because it believes the other side wants to, but only because it believes the other side may attack simply to pre-empt a supposed attack by the first (which is itself being launched as a pre-emptive attack). Schelling has labeled this situation, "the reciprocal fear of surprise attack."[4] As described, it is not a case of miscalculation, but a case of calculating correctly. This is clearly a situation in which each side has nothing to fear but fear, yet the knowledge that the other side is afraid fully justifies that fear.

Many things could touch off a "reciprocal fear of surprise attack" situation. The only reason I have put this possibility low on the list of possible causes of war is because of the belief that as long as decision makers are consciously in control of events, they are very much more likely to draw back from pressing buttons and accept any resulting risks, than to do something which would make war inevitable—particularly, if this war were to occur at a time and under circumstances not of their choosing. However, complicated and dangerous situations can occur. For example, suppose that one of our own Polaris submarines accidentally launched some missiles at our own country. Even if the submarine commander succeeded in informing us of what happened before the missiles landed, the accident could still cause a war. The Soviets might observe these missiles exploding and if they did know where the missiles came from, they might decide that it would be too dangerous to wait. Even if the Soviets knew that the missiles had not accidentally come from a Soviet submarine, they might not believe that we would wait to find out.

We might ourselves be under pressure to attack even if we thought the Soviets knew nothing about the incident because we could not be sure they did not know. It might appear safer to pre-empt than to let precious minutes slip away while we tried to persuade the Soviets that we knew they were innocent. The possibilities for trouble are almost infinite, and it would be wise to reinforce the natural caution of decision makers with explicit measures, both unilateral and multilateral, to facilitate communication and persuasion and to make waiting safe.

The line between preventive and pre-emptive war is sometimes very fine, and it is on this line that some of the most plausible war-making situations can occur. For example, let us imagine the Type II Deterrence situation discussed earlier, in which the Soviets were hypothesized as invading Europe, and we as evacuating our cities as a preliminary to delivering an ultimatum or otherwise exerting pressure. If the Soviets struck us at that time, it would not be a pre-emptive war, because very likely we would not have made up our own minds as to whether we would strike or not; in particular, we would intend to give them the option of backing down or compromising. However, we are so close to making up our minds that this cannot be labeled as a preventive war, either—a war to head off some

generalized future threat. Similarly, if after evacuating our cities, we gave the Soviets an ultimatum, and the Soviets chose the alternatives of prolonging the crisis, we might decide to strike, even though we thought there was a big chance that they were going to back down eventually. We would not be sure, and if we had already evacuated our cities, the risks of going to war would have been sharply diminished.

There is also a possibility of going to war simply to achieve world domination. Most people (the author included) believe the risks involved in going to war are so great today that no matter how promising an attack might look on paper, the "imponderables" and other "uncertainties" are large enough so that not even a moderately irresponsible decision maker would go to war for positive gains—though one like Hitler might. However, if we ever disarm, either unilaterally or bilaterally, to the point where the available weapon systems do not present the awful potentialities present today, then, of course, this possibility reappears.

Even if decision makers are unwilling to go to war for positive gains, they may still be willing to go to war, if, in their opinion, "going to war" is less risky than not doing so. There are many situations in which this could occur. One could imagine an internal or external crisis getting out of hand, and one which was being aggravated by the opponent, perhaps merely by his very existence. One may then be tempted to go to war, not because it looks so tempting, but because it looks like the least undesirable alternative.

Catalytic War.[5] The last possibility is the catalytic war. This is the notion that some third party (or country) may deliberately start a war between the two major powers for reasons of its own. As it is usually discussed, the concept holds that some power which is third, fourth, or fifth in the international hierarchy wishes to improve its position by arranging for the top two nations to destroy each other, thus moving itself up two notches. This is one of the major reasons why some people fear the dissemination of nuclear weapons to "ambitious" powers. However, there are several reasons why this particular concept is not considered plausible: (1) risks are so great for the triggering power that it is difficult to believe that one power could make and carry out such a decision, (2) more important, the United States and the Soviets will probably put into effect slow-reacting systems with a lot of stops in them before the decision for all-out war is reached. This means that it will be much harder for a third party to start a war than is often imagined, though if it tries hard enough and has a large enough capability, it is not impossible.

There is another type of catalytic war which I think much more likely and important: a desperate third nation thinks it has a problem that can be solved only by war. Let us imagine a war between India and China which the Indians were losing. The Indians might feel that if they induced the United States to strike at China and Russia, this would solve their problem, and any method they used to achieve this end was as good as any

other. Conversely, let us imagine a situation in which the Chinese felt hard pressed (possibly over Formosa) and told the Russians, "We are going to strike the United States tomorrow, and you might as well come along with us, for they will undoubtedly strike you, even if you do not do so."

As stated, the situation may seem somewhat implausible, but one can devise hypothetical situations which make it seem more plausible than I have done here. One may wish to broaden the definition of catalytic war. Any method by which a nation uses military or diplomatic power to embroil larger nations or increase the scope of the conflict could be called catalytic. By this definition, World War I was a catalytic war, set off by Serbia and Austria, which also had some overtones of "reciprocal fear of surprise attack" and "self-fulfilling prophecy," because the side which mobilized first was likely to win. It meant that even a defensive mobilization (by the Russians) touched off a defensive-offensive mobilization (by the Germans), in much the same way some believe that a badly designed, quick-reacting force can be touched off by defensive moves by the other side.

SOME HYPOTHETICAL ULTIMATES

[*Stability Is Not Enough.* Many experts and laymen believe that the best method of preventing any of the four potential causes of war from actually causing a war is to procure what are called "stable deterrent systems." This term implies a military posture which will deter a surprise attack and also not be accident prone or "trigger happy."] Even this limited goal is not enough for those strategists who also want stability against provocation (i.e., they also wish to have adequate Type II and Type III Deterrence). However, many strategists, and even some arms controllers, overlook the important requirement that a failure of stability should result in limited and "acceptable" consequences.

In order to illustrate this remark, I would like to discuss the strategic theory of three conceptualized devices, which I shall call respectively the Doomsday Machine, the Doomsday-in-a-Hurry Machine, and the Homicide Pact Machine. To discuss these hypothetical (almost allegorical) devices will not only focus attention on the most spectacular and ominous possibilities of the arms race, but it will also clarify a good deal of our current strategic thinking. In particular the discussion should make clear that:

1. The sole objective of maximizing deterrence is an unacceptable criterion for a weapon system;

2. There is a very difficult fundamental problem in deciding the permissible stakes at risk in the event of failure of deterrence;

3. Although current weapon systems are already quite disturbing, their potentialities could be dwarfed by some of the devices that may be practical in the near future.

The Doomsday Machine. A Doomsday weapon system might hypothetically be described as follows: let us assume that for 10 billion dollars one could build a device whose function is to destroy the world.[6] This device is protected from enemy action (perhaps by being situated thousands of feet underground) and then connected to a computer, in turn connected to thousands of sensory devices all over the United States. The computer would be programmed so that if, say, five nuclear bombs exploded over the United States, the device would be triggered and the world destroyed. Barring such problems as coding errors (an important technical consideration), this machine would seem to be the "ideal" Type I Deterrent. If Khrushchev ordered an attack, both Khrushchev *and* the Soviet population would be automatically and efficiently annihilated. (The emphasis is deliberate: most deterrents are more likely to destroy populations than decision makers.)

Even if this is the ultimate in Type I Deterrence, the Doomsday Machine is an unsatisfactory basis for a weapon system. It is most improbable that either the Soviet Union or the United States would ever authorize procuring such a machine. The project is expensive enough so that it would be subjected to a searching budgetary and operational scrutiny, one which would raise questions the project could never survive.

The Doomsday-in-a-Hurry Machine. Before considering these questions, let us consider how one might adapt the Doomsday Machine to purposes of Type II and Type III Deterrence. For reasons that will become clear, let us call this model the Doomsday-in-a-Hurry Machine. The computer would be given all the facilities it needed to be "well informed" about world affairs. We could then publish a "Soviet Criminal Code." This would list in great detail all the acts which the Soviets were not allowed to commit. The Soviets would then be informed that if the computer detects them in any violations it will blow up the world. The logicians (and some so-called practical men) might then believe that we had solved all our deterrence problems. After all, we would then have drawn a line the Soviets would not dare to cross. We could relax forever our interest in defense and turn our attention to other matters.

Unfortunately, the world is not that simple. First, the Soviets would rush to build their own machine. There would be a race to publish first. This race to publish first involves more than prestige. There is almost a certainty of an incompatibility between the two sets of rules, since Paragraph I of each probably states that the opponent shall not build a Doomsday Machine! To many people, to build a Doomsday Machine would be the greatest provocation short of an attack that the opponent could commit. In fact, because it may destroy so many people, some find it more provocative than an attack. Even if we succeed in publishing first, and even if the Soviets believe our machine will work as advertised, and are deterred from publishing, trouble is still almost certain. It will simply prove impossible to draw a useful, unambiguous line that covers most Type III Deterrence

situations—it may even be difficult to cover unambiguously all possible Type I and Type II situations. The first time there is a difference in interpretation the world would be blown up.

The Unacceptability of Doomsday Machines. Let us examine the use of both the Doomsday and Doomsday-in-a-Hurry Machines as deterrents. It is desirable that a deterrent should be: frightening; inexorable; persuasive; cheap; and nonaccident-prone.

As measured by these characteristics, both Doomsday Machines are likely to be better than any current or proposed competitor for deterrence. They are as *frightening* as anything that can be devised. They are more *inexorable,* since they can be made almost invulnerable to direct physical destruction (electromagnetic waves which would set them off go faster than shock waves which might destroy the device); the operation is in principle so simple and reliable that one can really believe it would work (as opposed to a complex weapon system which requires the split-second coordination and almost perfect operation of many complex parts in a strange post-attack environment); and the automatic operation eliminates the human element—including any possible loss of resolve as a result of either humanitarian consideration or threats by the enemy.

The machines are certainly *persuasive.* Even the most simple minded should be able to understand their capabilities. Most likely such machines would be *cheap,* compared to present weapons expenditures.

Finally, they are relatively *foolproof,* in the sense that the probability of an accidental or unauthorized triggering should be low. This means, while the possibility of an unauthorized or accidental use of the machine, in spite of all precautions, would be too high to be acceptable, it would still be lower than the probability of such an action in complicated and dispersed systems such as Polaris, Minuteman, and airborne alert. Not only is the number of buttons very low, but the Doomsday weapon system is so simple that one should be able to see clearly the places where trouble could occur, and then take all possible precautions.

The difficulties lie in the fact that the Doomsday Machine is not sufficiently *controllable.* Even though it maximizes the probability that deterrence will work (including minimizing the probability of accidents or miscalculations), it is totally unsatisfactory, for one must still examine the consequences of a failure. A failure will kill too many people, and kill them too automatically. There is no chance of human intervention, control, and final decision. Even if we give up the computer and make the Doomsday Machine reliably controllable by the decision makers, it is still not controllable enough. Neither NATO nor the United States, possibly not even the Soviet Union, would be willing to spend billions of dollars to give a few individuals this particular kind of life-and-death power over the entire world.

If one were presenting a military briefing advocating some special weapon system as a deterrent and examined only the five qualities on the

list, the Doomsday Machine might seem better than any alternative system; nevertheless, it is unacceptable. We thus see that our list of properties should have included a sixth: It is desirable that a deterrent should be *controllable.* The fact that most public discussion ignores this last requirement could imply that either some of the weapon systems currently being proposed are unacceptable, or that the way we talk about these weapon systems is wrong—very likely both.[7] Most decision makers seem to feel very strongly about the unacceptability of Doomsday Machines. If forced to choose among accommodation to the point of surrender, a large risk of surprise attack, or buying a Doomsday Machine, they would choose one of the first two as against the last one.

This last statement may surprise many who feel that irresponsible governments on both sides have already bought the equivalent of Doomsday Machines, almost without a second thought. I used to be wary myself of discussing the concept for fear that some overenthusiastic colonel would issue a General Operating Requirement or Development Planning Objective for the device. For whatever it is worth, my experience in two years of briefings has been exactly the opposite. Except for some intellectuals, especially certain scientists and engineers who have overemphasized the single objective of maximizing the effectiveness of deterrence, the device is universally rejected. Doomsday Machines do not look professional to senior military officers (in a way it threatens them with a fourth service), and they look even worse to senior civilians. The fact that more than a few scientists and engineers do seem attracted to such devices is disquieting, but as long as the development project is expensive, even these dedicated experts are unlikely to get one under way.

A Fundamental Problem. The concept of the Doomsday Machine raises certain awkward questions which must be considered by both policy maker and technician. If it is not acceptable to risk the lives of the *three billion* inhabitants of the earth in order to protect ourselves from surprise attack, *then how many people would we be willing to risk?* It is clear that both the United States and NATO would reluctantly envisage the possibility of one or two hundred million fatalities (i.e., about five times more than those in World War II) from the immediate effects, even if one does not include long-term effects due to radiation, if an all-out thermonuclear war results from a failure of Type I Deterrence. Under somewhat more controversy, similar numbers would apply to Type II Deterrence.* We are willing to live with the possibility partly because we think of it only as a remote possibility. We do not expect either kind of deterrence to fail, and we do not expect the results to be that cataclysmic if deterrence does fail. However, even those who expect deterrence to work might hesitate at introducing a new weapon system that increased the reliability of deterrence, but at the

* For example, Brennan would concede the statement for his B Deterrence, but not his C Deterrence. [Primarily because I believe we have the capacity to deal with failures of Type C Deterrence by drastically less expensive methods.—Ed.]

cost of increasing the possible casualties by a factor of ten, so that there would then be one or two billion hostages at risk if their expectations fail.

Neither the 180 million Americans nor the half billion people in the NATO alliance would be willing to procure a security system in which a malfunction could cause the death of one or two billion people. If the choice were made explicit, then the United States or NATO would seriously consider "lower quality" systems, i.e., systems which were less deterring, but whose consequences would be less catastrophic if deterrence failed. They would even consider such possibilities as a dangerous degree of unilateral disarmament, if there were no other acceptable postures. The West might be willing to procure a military system which could cause such damage if used in a totally irrational and unrealistic way, but only if all of the plausible ways of operating the system would not inflict anything like the hypothesized damage. Nor would we knowingly build a strategic system which forced the Soviets to build a Doomsday Machine in self-defense. On the other hand, we would probably be willing ourselves to go to desperate measures rather than give in to a cynical attempt by the Soviets to blackmail us by building or threatening to build a Doomsday Machine.

Possible Future Problems. Aside from moral and political reasons, and aside from the repugnance policy makers and practical men feel for a device that is poised to strike at their own population, the main reason the Soviet Union and the United States would not build a Doomsday Machine is that they are both *status quo* powers; the United States is one because it has so much, and the Soviet Union is one partly because it also has much and partly because it expects to get so much more without running any excessive risks. However, even if we believe that neither the Soviets, nor the Americans, nor other technically competent and wealthy but "satisfied" powers (such as England) would at present deliberately build a Doomsday weapon system, at least three important problems arise. Would a nation build one inadvertently? If not now, will it change its mind in the future? Would a determined non-*status quo* nation build one?

I do not believe that any nation will build a Doomsday Machine inadvertently, partly because it is so hard to build one, but mostly because current discussion is focusing attention on this problem, and decision makers are becoming conscious of its implications. As for a technically advanced *status quo* country's changing its mind, I could easily imagine a crisis in which a nation might desperately wish it had procured such a machine. Fortunately, it seems less likely that a nation would procure a standby capability that could be connected up at the last moment than that it would procure a continuous capability in being. The lead time for designing and constructing such a machine would be so long that the crisis would be settled before the project could get under way. In the long run (one to three decades), the third question, "Would a determined non-*status quo* nation build one?" may turn out to be the most important.

Many scientists believe that Doomsday Machines will inevitably become both clearly feasible and much cheaper than I have suggested, so that the developmental gamble will be much less risky than it is today. In addition, a number of powers which, unlike the United States and the Soviet Union, may not be cautious in outlook, will be getting both richer and more competent technically, yet may retain their non-*status quo* outlook. For example, there may be a nation (like the Germany of 1933) which is wealthy enough and technically competent enough to have an advanced military technology, yet desperate or ambitious enough to gamble all.[8] Or some of the underdeveloped nations may become rich in terms of gross national product, but have such a low per capita income or other social anomaly that they retain attitudes more appropriate to a desperate claimant on the world's resources than a responsible "bourgeois" member of international society.

China presents the outstanding possibility of this last type in the next decade or two. Such a third nation might well decide that an investment in a very high-quality Type I Deterrent would pay dividends. It is unlikely (though not impossible) that the leaders of that nation would plan on threatening the world with annihilation or extreme damage unless given their way. If they can do the damage gradually, they can make the threat clear and demonstrate their resolve, without actually committing suicide. As an example, suppose that the blackmailing nation started a process which it could reverse, but which could not be reversed or negated by others, in which the temperature of the earth was artificially dropped five degrees a year. If they also had a Doomsday Machine to protect themselves from attack (one which might depend on the same mechanism), one could easily imagine that they could demonstrate enough resolve to bring most of the other major nations to terms. A much more likely possibility for the possessor of a Doomsday Machine would be to exploit the sanctuary afforded by his "excellent" Type I Deterrent to be as aggressive as he pleased against his neighbors and to threaten any who interfered with all kinds of punishment—for example, some form of controlled nuclear retaliation, in which he destroyed two or three of the major cities of his interfering opponent. Even if it were feasible to retaliate in kind without setting off the Doomsday Machine, the social and political impact of accepting such losses would raise much more serious internal and external problems in the United States than in China. It seems most likely, for example, that having to accept and explain the rationale of an exchange of two or three major United States cities for an equal number of Chinese cities would result in political suicide for the party in power in the United States, as well as in some instabilities in our alliances, but only in some serious inconvenience to the Chinese government. It should therefore be a major objective of arms control to prevent such hypothetical, but not unimaginable, problems from occurring. (Here is one clear case of joint Soviet–United States interest.)

The Homicide Pact Machine. There is another hypothetical deterrent which, while not a Doomsday Machine, is still an "ultimate" of a sort. This could be called the Homicide Pact Machine, an attempt to make the failure of Type I Deterrence mean automatic *mutual* homicide. The adherents to this somewhat more practical device hope to divide the work of deterrence in a natural way—we poised to destroy the enemy and the enemy poised to destroy us, and neither of us buying any effective active or passive defenses for our respective societies.[9] The Homicide Pact Machine is clearly more satisfactory to both humanitarians and neutrals than the Doomsday Machine, and both should note the distinction. As far as patriots and nationalists are concerned, I believe that the Homicide Pact systems have many of the same drawbacks as the Doomsday Machine, though not in so extreme a form. The major advantage of the Homicide Pact is that one is not in the bizarre situation of being killed with one's own equipment; while intellectuals may not so distinguish, the policy makers and practical men prefer being killed by the other side rather than their own.

It is just because this view no longer strikes some people as bizarre that it is so dangerous. The Homicide Pact used to be, albeit only half-intentionally so, NATO policy and recently has come extremely close to being consciously adopted as official United States policy. It is not known to what extent the Soviets are planning to live up to "their part of the bargain" and move in the same direction. While Khrushchev's speech of January 14, 1960, indicated that Soviet decision makers have begun to accept some of the concepts of deterrence which have so persuasively swept the West since the mid-fifties, there is no indication that this acceptance will lead to a relaxation of current Soviet attempts to attain a capability of fighting and surviving wars as well as of deterring them. The opposite may be true. The main point of the speech was not that the Soviets were disarming, but rather that, by cutting back on conventional capabilities, they would gain in their capability to fight a modern thermonuclear war. Whether this is the somewhat misleading "more bang for the buck" program we once followed or a serious attempt to be prepared for any eventuality, only time or Khrushchev can tell.

THE ARMS RACE ITSELF

In discussing the Doomsday Machine as a weapons system, including computer and sensors, I have ben dealing with a somewhat romanticized and (one hopes) very remote possibility. I have spent so much time on it partly to highlight and satirize some current strategic notions (e.g., some extreme forms of Finite Deterrence). For this reason, much of the section on "hypothetical ultimates" has been cast in a "reassuring" tone; but the mere fact that one feels it necessary to discuss soberly the use and construction of Doomsday Machines indicates in the most dramatic manner that the current arms race has changed in character

from previous arms races. The issues are bigger and may eventually come to the stage of Doomsday Machines or close approximations of these devices. While this possibility now seems rather remote, if the event should ever transpire, it would of course constitute *the problem* of the twentieth century. However, one does not have to allude to the Doomsday Machine to be concerned about the arms race and current capabilities. Our normal military forces are frightening enough, and they are improving rapidly (though in some ways the newer systems—Polaris and Minuteman—are less destructive than the old ones).* The most spectacular thing about the arms race is that it *is* a race, and one that is being run with some celerity.

This is also a new thing. There has been some tendency in the past for the military to exploit the products of civilian research and development, but this attempt has been remarkably lackadaisical. There has been even less research and development done specifically for war. (The common belief that the search for improved weapons has been a major source of technological progress seems to be grossly exaggerated, at least for periods of peace, though long wars such as the American Civil War and World Wars I and II did see technological advances spurred on by the requirements of the war.) Previously, really big wars have tended to occur twenty and thirty or more years apart, and there has been a tendency for each war to start where the last one left off or even with more ancient techniques.

Even so, each war has brought startling and unexpected surprises. (For example, the development of the most characteristic feature of World War I, the long line of trenches stretching from the Alps to the English Channel, seems to have been considered by only one writer, Jean de Bloch, and though widely read, he had no impact on military planning.) Now, for the first time in history, we are having a complete technological revolution in the art of war approximately every five years. As a result, we are now three technological revolutions away from World War II. Any attempts to apply the concepts and rules of common sense derived from that experience run the grave risk of being as outmoded as some American Civil War concepts would have been in World War II. In so far as we are trying to plan for the late 'sixties and early 'seventies, we are projecting into an environment which is two or three revolutions ahead of where we are today. An examination of the development of military doctrine in the postwar years, in both the official agencies and the *avant garde,* indicates that the possibility of great success in such planning is not high. While doctrine has evolved with meteoric speed as contrasted with the rates before World War II, it has been hopelessly behind events rather than successful in anticipating the future. I will not try to describe this process in any detail, though I would like to describe the technological revolutions, so as to emphasize the difficulties both we and the Soviets have in understanding and coping with just the military environment in our search for security.

* This is because of weight restrictions on the warheads for these missiles, not because of humanitarian considerations.—ED.

The Technology of 1951. Let us start with the situation in 1951, a convenient date to mark the first peacetime revolution. What follows is a very partial list of the new possibilities (with particular reference to the United States and air warfare) that the military planner (or arms controller) of 1945 would have had to anticipate by 1951: third- or fourth-generation fission bombs; the B-50 and B-36, forming the backbone of the United States SAC; the initial production of the B-47; the first flight of the XB-52; a manual air defense system started; air defense having F-80, F-84, F-86, F-94; production order for Nike A; experimental aerial refueling; a nuclear-powered airplane under development; many organizations, in and out of government, formed to institutionalize innovations in air warfare and to rationalize research, development, procurement, and operation; the Russians possessing TU-4 and MIG-15, and having tested three nuclear weapons.

I will discuss only a few items on the above list and on other lists to be given later, but the whole list will remind us of the complexity and speed of the arms race.

The most pressing questions involve the impact of fission bombs. These devices had had a very vigorous development program, and in 1951 we had third- or fourth-generation models available. Would their use have been decisive or not? The Soviets did not think so: they talked smugly of the "permanently operating factors" and the impracticability of blitz-krieg tactics. Many Americans, particularly the advocates of air power, tended to think that nuclear weapons would be decisive, but we had not bothered to get as many bombs as we could or (from the strictly military point of view) should have. Of course, the Soviets had gone into a vigorous development and procurement program for nuclear weapons. But they did not seem to have made any preparations specifically designed to meet the threats that nuclear weapons pose, though they had done a great deal to meet conventional threats typical of World War II.

In 1951 there was still much talk of the scarcity of uranium, a view which was reinforced by most of the technical people. Few people in or out of government thought of the atom bomb as soon being plentiful; nobody realized that practical and convenient thermonuclear bombs would be available before long. But a few people with high security clearances knew that some work on a rather impractical thermonuclear device was going forward. Though there was some discussion in 1951 about "baby atom bombs" with about the same power as the Hiroshima and Nagasaki bombs but much smaller in both weight and size, not even the experts had any idea of the flexibility, efficiency, and economy soon to be available in the atomic weapons arsenal.

Almost all 1951 discussions of defense against nuclear weapons assumed that the bombs were too precious to be used on anything but important cities or the most valuable production targets, such as Oak Ridge and Hanford. Similarly, NATO planned on the assumption that nuclear weapons

would not be generally available for the European theatre except for very special and very high priority targets. However, a few economists were already pointing out that since there was a large disparity between the value of uranium and the marginal cost of production, there was every reason to imagine that much more uranium could and would be produced. There was even some reason to suppose that this large increase in production would be roughly at current prices. Most of the military, the scientists, and the engineers did not think that way.

This overvaluation of bombs as being too precious to use on military targets affected defense planning in our Zone of the Interior. Because of the threat of Soviet attacks, the Air Defense Command and the associated Army Anti-Aircraft Command was set up in Colorado Springs in 1951, but they thought of their highest priority job as the defense of large cities and nuclear facilities; the initial deployment of their facilities (radars and fighters) almost ignored warning and defense for SAC in the event of a surprise attack directed at SAC and not at the cities.

In spite of the emphasis on short wars it was not until 1948 that we seriously started to mold SAC into an ever-ready instrument of war. (The accession of General Curtis LeMay to the command of SAC and the Berlin Blockade apparently played the main roles.) We had not quite finished the process by 1951. Neither had we accepted the implications of the Soviets' testing of an atom bomb. For example, the official point of view (to be reflected soon in the investment of some 11 billion dollars in war reserve tools and raw materials), as opposed to that of the air-power enthusiasts, held that an all-out war of the mid-1950's would be long—from three to five years—even though initiated with atomic weapons.

While it is easy to show that most of these planners had not thought about the problem and were just reacting in a World War II fashion, given the official asumptions as to the scarcity of bombs, they may well have been right about the length of the war. Nobody could show just by physics and engineering that a small number of fission bombs dropped on Russia would in fact have caused them to sue for peace. In fact, one could almost have shown the opposite: that the Russians accepted much more damage in World War II and continued to fight, so that unless such imponderables as the psychological and disorganizing impact of using even a small number of bombs were great, a long war would have been possible.

One thing was almost always completely overlooked in 1951: the possibility that war could have broken out under such circumstances that the United States might not have succeeded in using very many bombs. We had only a small number of SAC bases (18 in 1950,[10] including some strategic fighter bases that did not pose a serious threat to the Soviets) and no organized warning system worthy of the name. (There was not even a Ground Observer Corps, for this organization dates only from July 14, 1952.) Furthermore, under normal conditions, SAC operated unalerted and would have taken some hours before it could get its planes into the

air just to evacuate—even longer before the airplanes could have been prepared to go on a mission. Under these circumstances, just a handful of Russian planes carrying a very small number of atom bombs might well have been able to wipe out a large segment, possibly approaching 100 percent, of our strategic military power in a few hours. (I use the term "few hours" deliberately. The Russians needed no superb coordination or piloting to do this task. They simply had to be able to fly from one point to another point, more or less on a Great Circle route.)

In some ways the lack of concern in 1951 for the ground vulnerability of bombers was surprising. Many people had written or lectured about the importance of our having a secure and invulnerable SAC. Furthermore, it was part of both Douhet * and Air Force doctrine that war in the air is decided by the destruction of the enemy air force on the ground. Last, less than a decade had passed since the "bolt out of the blue" at Pearl Harbor. Nevertheless, there was a real doctrinal lag, which by the mid-fifties was just being made up. It is rather interesting that it was the advent of the ICBM, rather than the fact that the Soviets had acquired a strategic bombing force, that persuaded most people to think the vulnerability problem through and learn to distinguish between First Strike (attack) and Second Strike (retaliatory) forces. As long as the problem had any subtlety at all, most people managed to ignore it. One wonders what subtle doctrinal lags exist today.

It was quite true in 1951 that even though the Russians had the basic equipment they needed—the bomb, and a plane which when refueled could reach its target—they probably had neither the tactical knowledge, the operational capability, nor the strategic doctrine which would have enabled them to launch such an attack out of the blue. In fact, given their strange lack of emphasis on aerial refueling (an absolute must for any Soviet war planner devising an attack on the United States), one could have argued that the Soviets were basically planning to refight World War II, and, for example, had built hundreds of submarines to stop convoys of the type of World War II.

In addition, Stalin and his military advisers seem to have been reasonably, if not excessively, cautious. They were willing to fill power vacuums and press relentlessly, but not too aggressively. They were willing to take small but not large risks. There is even evidence that they tried to restrain the Yugoslav, Greek, Indochinese, and Chinese Communists from being too provocative.

However, it also seems likely that Stalin's caution did not stem from fear of the atomic bomb as a decisive weapon. What alarmed him about the United States was Detroit—not SAC. He appears to have been convinced that no sensible government should tangle with a nation that had a gross national product of 350 billion dollars a year. We had both assets, the

* Douhet was an Italian strategist who developed in the 1920's much of the airpower strategy later used in World War II. See Bernard Brodie, *Strategy in the Missile Age*, Princeton University Press, 1959.—ED.

bomb and the GNP, so that any difference between the point of view of the United States and the Soviet Union was not crucial.

It should be quite clear, even from the superficial discussion above, that any arms-control system set up in 1951 might easily have been based on some serious misunderstandings of the implications of the technology then current, and on even more serious misunderstandings of the future. In particular, some kinds of inspection schemes might have resulted in making our vulnerabilities both crystal clear and very tempting to Stalin or some of his military advisers. Even to force the Soviets to go through the intellectual exercise of thinking these problems through might have been dangerous. Before we could have safely started discussion of "the control of surprise attack," we would have had to fill in the gaps in our defense posture—that is, engage in a limited rearmament program.

The Technology of 1956. Let us now look at the technology of 1956. It included such factors as: third-generation thermonuclear bombs; three nuclear powers; the last B-47E produced; B-52 and KC-135 being phased into SAC; B-36 being phased out (the last B-36J was produced in August 1954); B-52D in production; B-58, Snark, and XP6M-1 (Martin Seamaster) flying; Regulus I, Nike-Hercules, and Falcon missiles in service; Atlas, Titan, and Thor in crash programs; many other missile programs in progress; Century Series of fighters (F-100 to F-104) being phased into the Air Defense Command; the DEW line being built; MB-1 (nuclear warhead for air-to-air rockets) being tested; production order for Missile Master and SAGE; classified intelligence projects such as the U-2, Turkish Radar, etc.; an atomic-powered plane and rocket under development; an atomic-powered submarine launched; research and development becoming the major business of the aircraft industry, and procurement becoming secondary; the Russians having the Badgers, Bears, Bisons, IRBM's, and their own models of H-bombs.

The most startling change was the development and perfection of thermonuclear bombs. Probably this introduced a more radical change into the technology of war than the introduction of the atom bomb did. The difference between megaton and kiloton is very large, in some ways relatively larger than the difference between kiloton and ton.

The effect of the innovation shows up in the nature of the questions one tends to ask. For kiloton bombs, one asks how much is destroyed—but, barring an extreme course of military events, no one doubts the the nation will continue in some form. With multimegaton weapons, the question of the continuation of the nation (to some, of civilization) is raised even in the shortest of wars. Megaton weapons are comparable to gross forces of nature such as earthquakes, hurricanes, etc. The prospective effects of the use of such weapons are not only extremely widespread, they are also occasionally very subtle and hard to predict. As a result, for the first time in the history of war we have what might be called *the problem of the post-attack environment.* Partly because of one of these environmental effects

(fall-out), and partly because we had not thought about or prepared for nonmilitary defense including recuperation, it is most unlikely that the United States really possessed in 1956 and later years much objective Type II Deterrence. But nobody knew it, so we did not suffer any disastrous losses in 1956. However, the instability of such psychological capabilities began to show up even before the next technological revolution in 1961.

Let us look at this notion of post-attack environment in more detail. Multimegaton bombs are so powerful that even if they do not destroy a system, they may damage it by some subtle effects or so change the environment that the system will be temporarily inoperable. The various effects of nuclear weapons include blast, thermal and electromagnetic radiation, ground shock, debris, dust, and ionization—any of which may affect people, equipment, the propagation of electromagnetic signals, etc.

It is quite possible that some of our current systems may have important hidden defects that will only be disclosed by an attack. In the last few years I have worked on several weapon systems in which new weapon effects or new interpretations of old weapon effects were found that had not been thoroughly allowed for and which could have been disastrous. I therefore find it hard to believe that we have uncovered all of the problems from which our systems may suffer. An extreme dependence on such theoretical investigations as a substitute for (unobtainable) experience can be dangerous. For example, imagine that our total posture has ten serious weaknesses in it, but by dint of hard work and much investigation we discover nine out of ten of the weaknesses and correct them. Imagine also that the enemy is trying to find these same weaknesses and succeeds in finding nine of them. Unless the overlap is complete and we have found exactly the same weaknesses, then the enemy has discovered a weakness which he can exploit. If the processes involved were purely random, there would be a 90 percent probability that the enemy had found the one weakness we failed to correct. In practice, the situation should not be that bad: the weakness that was hard for us to find is probably just as hard for the enemy to find. But even if the enemy does not find some weakness that he deliberately exploits, it is not at all clear that we will be able to predict the post-attack environment in enough detail to be able to take into account adequately all of the phenomena that will occur.

Technological Advances by 1961. Let us now glance at some of the technology we shall be facing in 1961: arms control (techniques and capabilities); satellites, such as Tiros, Transit, Notus, Discoverer, Pioneer, Mercury; soft Atlas and soft IRBM's deployed; 25-psi Atlas, 100-psi Titan, and Polaris being phased in; several guidance "breakthroughs"; a crash program on Minuteman and other second-generation missiles; B-47E, B-52H, B-58 forming the bulk of SAC; BMEWS being phased in; Goose, Navajo, Regulus II, Seamaster, etc., canceled; SAC operating alert and dispersed; inexpensive, efficient, and versatile bombs; four nuclear countries; SAGE and Missile Master partially deployed; Bomarc A and Hawk

being phased in; Nike-Hercules, F-100, 101, 102, and 104 in service; limited Civil Defense (?); X-15 test vehicle; a nuclear-powered plane and rocket still under development; experimental nuclear explosives; the Russians having . . . ?

The year 1961 will find arms control having some influence on our military posture. On October 31, 1958, the United States suspended the testing of nuclear weapons, and 1961 is likely to be the third year of no weapon-development testing on the part of the United States. Thus, 1961 should be the third year of an uninspected moratorium, and, in addition to all the other uncertainties of a United States military planner, there will be such questions as, "Are the Soviets cheating? If so, to what extent? And what is the military significance?" Even if a treaty were to be signed by the time this book is published it will take a period of from two to five years to install and proof-test whatever inspection network is agreed upon.

The test-suspension negotiations at Geneva illustrate the importance of doing our homework. In July and August of 1958, the Western and Eastern experts at Geneva agreed, after a short hectic conference (at which most of the technical facts were worked out in late evening sessions) that about 180 stations around the world (about 21 in the Soviet Union) would suffice to pick up illegal explosions greater than 5 kilotons in yield. Within months, on the basis of new data and experiments, the Western experts decided they had been off by at least a factor of four. A few months later, several ingenious schemes (testing in big holes or outer space) were worked out to evade the proposed inspection system almost completely, as far as tests of the kiloton type were concerned.

From the viewpoint of arms control, one of the most dangerous innovations of 1961 is the possibility of the experimental use of nuclear explosives in one or more peacetime applications. In May 1959 the Atomic Energy Commission sponsored the Second Plowshare Symposium on the Industrial and Scientific Uses of Nuclear Explosions. At an earlier symposium there had been much interest in the subject, but nobody expected anything to happen very soon. By the second one, many of the ideas had had time to mature. There were about fifty papers presented at the symposium on various aspects of nuclear explosives. The suggestions for peaceful uses of nuclear explosives included: artificial harbors, sea-level ship canals, underground oil storage, power, isotope production, geothermal steam plants, salt water distillation, improvement of underground water supplies, mining, shale oil production, meteorological experiments, and other scientific experiments.

The length of the above list should not surprise the reader. Nuclear explosives are a uniquely concentrated but very simple and relatively cheap source of power, heat, and pressure, as well as of neutrons and other radiation. Once they become even slightly available, many people will look for and find applications for these new devices, which in turn will make them even more available. In fact, the terms on which they are

available at this writing were spelled out by the AEC at the Second Plowshare Symposium as follows: roughly a half million dollars will buy explosives in the low kiloton region, and perhaps a million dollars will buy them in the low megaton region. The AEC is careful to note that the above charges are for small quantities.

Very few people at the 1959 symposium would have accepted even odds that a number of the ideas discussed would not be in programs by 1961. In particular, a project to dig an artificial harbor in Alaska is definitely programed at this writing. Since some of the individual projects promised to use hundreds or even thousands of bombs, it is not impossible that even a private international market of buyers and sellers of nuclear explosives could eventually spring up. This last is particularly likely if there is technological progress in the design of very simple bombs made of readily available materials. Once there develops a legitimate market for nuclear explosives, then in the absence of controls many nations will manufacture them for sale or peaceful use, if not by 1970, then by 1980. However, unless one of these nations is very irresponsible, there should be a fair degree of voluntary control over the distribution of these devices.

I will discuss later some of the problems that might arise as a result of the possible dissemination of nuclear weapons. I should point out that at the present writing, however, it is rather unlikely that nuclear explosives will be as successful as I have indicated they might be. As Lewis Bohn has pointed out to me, the above discussion mirrors almost exactly the early (incorrect) postwar expectations on the speed of development of nuclear reactors and the consequent strategic and control problems. Much of the Baruch Plan for the control of nuclear weapons was preoccupied with this much overestimated problem.

I believe that a much better economic and technical case can be made for the use of nuclear explosives than could be made for the early postwar reactors. In addition, there is a much smaller distance between a nuclear explosive and a bomb than between a reactor and a bomb. In the first case, the distinction is often a semantic one; in the second case, one may need a major chemical industry. I therefore believe that if nuclear explosives do not present a problem, it is likely to be because of legal, social, and political obstacles to this development rather than technical and economic ones. This is one place where the pursuit of a higher standard of living for all may result in a drastic reduction.

The Mid-1960's. We have just been looking somewhat superficially at the early 'sixties. I would like to give only a bare listing of the possibilities of the mid-sixties, labeled 1965 for the sake of definiteness. (The reason there are only four years between this technological revolution and the last—I had been using five years between these revolutions—is that technological innovation seems to be even faster today. We are spending more money on research and development, and getting more skillful in its management.) By 1965, then, we would expect to have some of the following:

independent nuclear deterrents; Minuteman B and Polaris C; second-generation Atlas and Titan; Dynasoar; BMEWS-B, Midas, and SAMOS; protected B-52G and H, B-47E, B-58A and B; the limits of bomb technology (if testing is continued); commercial nuclear explosives; an airborne ballistic missile; super-guidance; SAGE B, Bomarc B and C, Nike-Zeus A and B, Hawk B, F-108, B-70 technologically possible, but perhaps canceled; antiradiation drugs; protected command and control; exotic fuels and propellants; an inexpensive reliable research missile; inexpensive satellites; a nuclear-powered airplane(?) or rocket (?); experimental climate control; bacteriological and chemical warfare; and astronauts.

The 1970's. Rather than comment on any of the above, I would like to deal with some of the possibilities for the late 'sixties and early 'seventies, which I will label 1969. We now have to take into account more than just the extrapolation of current technology. We have to consider the possibility of "breakthroughs" and other surprises. Although it is not possible to limit or describe in advance what breakthroughs might occur, it is possible to discuss some projects currently being studied which might be called breakthroughs, if successful. This method of trying to estimate the total impact of technological progress is likely to involve some large underestimates of the total change, since one can almost guarantee that many startling and unexpected developments will occur. I will try to make up for this by some judicious exaggeration in the areas to be discussed, for such an exaggeration will give a better "feel" for the over-all possibilities for the late 'sixties or early 'seventies than a more sober discussion of the few items I will consider: cheap, simple bombs; cheap, simple missiles; cheap satellites; controlled thermonuclear reaction; other sources of cheap neutrons; other sources of nuclear fuels; californium bullets; ground-effect machines; reliable sensors; super-calculators; cheap calories; medical progress; advanced materials; cheap, fast transportation (for limited wars); reliable command and control; Doomsday Machines; and disguised warfare.

When we enter the 1970's, the most advanced nations at least will know in theory how to make simple bombs and missiles, and in the absence of explicit or implicit controls will be making them in practice. For this reason, I have put cheap simple bombs and cheap simple missiles at the top of the list because, even with arms control, and certainly without it, these are likely to be the most characteristic features of the late 1960 or the early 1970 period. They may or may not present the most important (and dramatic) problem. This will depend on which nations actually have weapons in their stockpiles, on the explicit and implicit controls, and on the state of international relations.

Under the current programs, 1969 may be a little early for the diffusion of these devices to other than "advanced" nations. It is very difficult to predict the rate at which the technology, materials, and information will be disseminated. Even without explicit controls, it might be the mid-1970's or even a later period before they become cheap and simple for

the majority of "developed" nations. But there are many things that could accelerate this dissemination process: the use of nuclear weapons in a limited war; successful programs for the peaceful uses of nuclear explosives in the mid-1960's might at least make nuclear "devices" widely available; the deliberate diffusion of nuclear technology, by either the United States or the Soviet Union, to enough allies so that there will be no more secrets; a breakthrough in technology or materials, etc.

As an example of this last possibility, consider the fusion reactor. It is improbable that this device will be practical by 1969; most experts in this field are somewhat doubtful about any real success before the year 2000. Let us, however, go ahead and outrage the experts by assuming not a qualified, but an outstanding success—such a success that even relatively primitive nations will find it possible either to build or buy a fusion reactor and thereby to acquire a virtually unlimited source of cheap power. This spectacular gift of technology has a significant side effect: it gives off neutrons very copiously, so copiously that it may not be exaggerating to state that the neutrons are for all practical purposes free.

Free neutrons would mean that many kinds of nuclear fuels would be very cheap. With these nuclear fuels and with the kind of technology that is likely to be available in 1969, it may literally turn out that a trained and technically minded person, even one who is a member of a relatively primitive society, would be able to make or obtain bombs. This would raise forcefully the question of the illegal or uncontrolled dissemination of bombs. (One can today buy machine guns, artillery, tanks, and fighter aircraft on the gray market.) Thus the 1969 equivalent of the Malayan guerrillas or the Algerian rebels or the Puerto Rican nationalists, or even less official groups such as gangsters and wealthy dilettantes, might be able to obtain such bombs.

Even if the controlled thermonuclear reaction does not prove to be a success by 1969, there are other possibilities for the cheap production of neutrons. For example, many of the commercial uses of nuclear devices would release neutrons as a by-product. This might lead to either the clandestine or open production of weapon-grade nuclear fuels. There are also possibilities that simple and inexpensive methods for producing weapon-grade nuclear fuels will be developed. It is also possible that we and others will learn how to make bombs using only or mostly materials already widely available, such as deuterium and lithium. (The widely discussed small "clean" bomb would probably use such materials.) In a word, 1969 (though more likely 1979) may see the introduction of the era of the conventional nuclear bomb in which (in the absence of adequate controls) any "legitimate" nation can get some models, and some illegitimate groups or governments may also get access to nuclear weapons, but presumably under more onerous conditions than those to which legitimate purchasers are subject.

Consequences of the Spread of Weapons. We may be too frightened

of the possible consequences of the widespread diffusion of weapons. It is quite clear that if one gave the Egyptians and Israelis atomic weapons, one is likely to find both nations acting much more cautiously than they do today, simply because the consequences of "irresponsibility" would be much more disastrous. On the other hand, even a greatly increased sense of responsibility may only mean that, instead of falling upon each other the week after they come into possession of these weapons, the attack may be deferred for a year or two.

In fact, almost any sober analysis indicates that it is somewhat harder for "Nth" countries to cause a cataclysm than is often believed. It is difficult to imagine that China or France, for example, could in the next decade obtain a large enough strategic force to strain United States Type I Deterrence seriously, although the situation in the 1970's and 1980's could become much more difficult. It is ~~even~~ difficult to imagine one of these nations being able to start an accidental war, if the Soviets and the United States have made sensible plans to prevent this eventuality, and it is a little difficult to understand why they would want to start one, unless they were in some kind of a crisis which would be helped by such an action. In this last case, the Soviets and the United States would be likely to be on their guard.

All of the above may be true. Even though it is going to be difficult to get nations to make the necessary concessions until the dangers are both more apparent and more pressing than they are today, nevertheless, I believe that we should still try to make international arrangements *before* the weapons have been distributed, rather than *afterward.* While it is quite possible that many laymen overestimate the immediate impact that the widespread dispersion of weapons will have, I strongly suspect that the "sober" analysts underestimate both the immediate and long-term problems. I will list ten such problems here. It would not be difficult to list many more.

In a nuclear world, the "small" powers, vis-à-vis one another, would have: greater opportunities for blackmail and mischief-making; greater likelihood of an accidental triggering of weapons; an increased possibility of a "local" Munich, a Pearl Harbor, and blitzkriegs; pressures to preemption because of the preceding three items; a tendency to neglect conventional capabilities because of an overreliance on nuclear capabilities; internal (civil war, a *coup d'état,* irresponsibility, etc.) and external (the arms race, fear of fear, etc.) political problems.

Nuclear diffusion to small powers would also: create a situation in which the diffusion of nuclear weapons to irresponsible or criminal organizations and individuals is facilitated; complicate future problems of control by making such control involve the small powers' having to accept an obvious reduction in their sovereignty (that is, they would give up something, rather than abstain); give the Soviet Union or another large power many opportunities to act as agent-provocateur; and create the

capability, and therefore the pressure, for many nations to make a crisis serious or to exploit an ongoing crisis (such as by catalytic war or escalation).

In short, the diffusion of nuclear weapons may or may not increase the number of crises, but it will almost undoubtedly tend to increase the seriousness and the grim potentialities of any crisis or even the misunderstandings that do occur, besides increasing enormously the importance of having responsible and competent governments everywhere.

The widespread possession of nuclear weapons and delivery systems strikes many observers as similar to situations in physics that may be described as semi-stable equilibrium. For example, imagine a ball balanced on top of a small cup so that small movements of the ball can be tolerated, but not large ones. If this ball on the cup is isolated, it might sit there on top of its cup forever, but if it is submitted to the vagaries and chances of a sufficiently uncontrolled environment, one can guarantee that sooner or later it will fall. This may be true even though every "reasonable" analysis of the situation that looks at probable or plausible disturbances showed that the forces were in close enough balance so the ball should stay where it is. It takes an improbable or implausible force to topple the ball. But some improbable and implausible events will occur and, barring a major change in the situation, almost certainly the ball will eventually fall. While the analogy may simultaneously be apt and yet misleading, many who have thought about this problem have come to the conclusion that reliable stability can only come through an international agency with an effective monopoly of force.

For many reasons, I do not believe that the twentieth century will see a disarmed world, but it may see a world government or the equivalent.[12] Until that day arrives, it will be of great value to try to keep, indeed *make*, the problem of national security intellectually and diplomatically simple, and the diffusion of nuclear weapons would seem to go exactly the wrong way. The "two-power" case seems both intellectually and practically more controllable than the "N-power" case. The diffusion of nuclear weapons not only complicates the over-all "analytic" problem, but the stakes at risk if events go badly would seem to be less in the "two-power" than in the "N-power" case.

CONCLUSION

In this chapter I have scarcely been able to touch upon the complexities of the technological arms race and the stability of the United States–Soviet balance of terror. I have tried to point out that technological progress is so rapid that there are almost bound to be doctrinal lags. These doctrinal lags will in themselves be dangerous, leading to important gaps in our preparations, the waste of badly needed resources on obsolete concepts, the neglect of possible strengths, the excessive use of especially glamorous

tools, and, possibly most important of all, heightened possibilities of serious miscalculations or accidents because we have not had time to understand and make provisions for the requirements of the newly installed systems. To the extent that arms-control measures are supposed to alleviate dangers or costs by allowing the current "balance of power" status and military competition to be conducted, by agreement, at cheaper or safer levels, or to the extent that one hopes to increase each state's objective capability of preventing surprise attack or other disaster, this inability to understand "the military problems" introduces almost intolerable complications. (The reason for the adverb "almost" is that we have these complications, whether or not we have arms control.) I have almost ignored the even more complex problem of the conduct of international relations in a world in which force is becoming both increasingly more available and increasingly less usable, a problem that is complicated by the spectacular increase in the number of sovereign nations, by increased nationalism, militarism, and "ambitions" in these new nations and governments, and by the revolution of rising expectations.

Any attempts to control the arms race must be able to live with all the stresses and strains that the above problems will create. It is most unlikely that all of these problems will be solved in an atmosphere of good will and common fellowship, or by the use of *ad hoc* committees and intuitive judgments derived from experience in almost irrelevant situations. And we may not have much time in which to work.

6. The Feasibility of Arms Control and the Principle of Openness

EDWARD TELLER

THE ISSUE OF PEACE IS RIGHTLY UPPERMOST IN THE MINDS OF OUR generation. Those of us who have participated in the invention of modern means of destruction feel a special desire to contribute toward peace as best we can. In the popular mind peace and arms control are closely linked. It is clear, however, that disarmament is desirable only to the extent to which it will promote peace.

THE RELATION BETWEEN ARMS CONTROL AND PEACE

Historically it would appear that the relation between arms control and peace is dubious. Most people believe that World War I was brought about by an arms race. There is good evidence to support this view. On the other hand, there can be little doubt that World War II was caused by an uncontrolled race for disarmament. The peace-loving nations disarmed; thereby they gave one lawless government a chance to bid for world domination. Historical analogies are not conclusive, but it seems to me that it is more valid to compare the present situation with the history of the 1930's rather than with the history of the early years of our century.

There are many well-known arguments both for and against arms control. Perhaps the strongest driving force toward arms control is the conviction that without it a world catastrophe of unimaginable magnitude cannot be prevented. It is hoped that an arms-control agreement can prevent the further spread of the knowledge of nuclear explosives. It is argued that arms control is in the interest of both the Russians and ourselves, and therefore we can come to an agreement. It is hoped that arms control will be a first step toward increasingly friendly relations and genuine cooperation between all people in the world.

On the other hand, arms control may well lead to a change in the balance of power with the result that the Russians could gain overwhelming superiority. This can happen by reducing those categories of arms in which we enjoy an advantage. Or else it may happen that the arms-control agreement

cannot be enforced; it may then be observed only by our side but not by the Communists.

Finally, it may be urged that the regulations and the policing which will have to accompany arms control will give rise to suspicions and to friction. Thus arms control would become a source of irritation rather than a first step toward peace.

There is no doubt in my mind that human contacts between all people will promote the cause of peace. This is particularly true if these human contacts lead to positive and valuable accomplishments. Joint work on medical problems or on the exploration of our globe and the oceans of air and water are cases in point.

On the other hand, it is undeniable that disarmament may lead to frustration, friction, and failure. Therefore, there is at least some doubt whether or not arms control is the proper first step in creating a peaceful atmosphere.

A THIRD WORLD WAR

That a third world war would be catastrophic cannot be questioned. Some people have argued that it is better to surrender than to risk the dangers of such a war. This point of view cannot be attacked on the basis of logic. But, in viewing it, it is relevant to reflect how catastrophic a third world war may in fact be.

Extremely little thinking has gone into the question of passive defense against an atomic attack. I believe that an extensive shelter program would save the great majority of the people in the United States even in case of a most ferocious attack. It is certain that such an attack would wipe out our industries, but past experience as well as some research on the question of possible reconstruction have shown that the United States could recover from an all-out attack in a small number of years. This, of course, could be done only if we prepare properly. It is estimated that forty billion dollars, which is equal to one year's military expenditure, could go a long way toward insuring the survival of our nation. Twice that amount would make our passive defense satisfactory. Unfortunately, we are now spending for passive defense an amount which is approximately one-thousandth of our military expenditure.

It is, of course, of paramount importance to avoid the great suffering that a third world war would cause. But it does not seem proper to state that there are no alternatives to surrender. Arms control is justified only in so far as it decreases the probability of war without creating a situation in which surrender will become inevitable.

THE SPREAD OF NUCLEAR WEAPONS

A short time ago we were worried about the fourth-nation problem. We are now faced with the fifth-nation problem. How long or how short a time

12. Policy Considerations of a Nuclear-Test Ban

DONALD G. BRENNAN AND
MORTON H. HALPERIN

INTRODUCTION

IN THIS CHAPTER WE SHALL DEAL WITH THE MAJOR POLICY CONSIDERATIONS of a ban on the further testing of nuclear weapons.* Many of the issues involved in such a ban have become extremely controversial. The primary objective of this chapter is to illuminate the relevant issues of policy as completely as space permits. There are some genuine potential costs of a test ban, and we have tried at least to indicate these, so far as we know them. However, sufficient technical information is now available to enable us to indicate just how serious these costs might be. In our opinion, these costs at worst do not outweigh the possible gains of a test ban, at least for the next five or ten years.

Another objective of this chapter is to provide an example of a fairly complete analysis of an arms-control measure. As such things go, it is a rather simple measure, and the analysis will indicate the potential magnitude of the problem of analyzing more complicated measures. Simply as an example of a fairly complete analysis, this chapter may be of value even if a test-ban treaty is signed and ratified by the time this book is published—which seems rather unlikely. And some of the issues involved are likely to remain live issues even if a treaty *is* signed and ratified. Since a rather detailed summary of the negotiations up through the fall of 1960 has been published,[1] we shall confine ourselves to the substantive issues, which for the most part have not been adequately discussed elsewhere.

Finally, we cannot emphasize too strongly that the present analysis is of *a test ban as a limited measure,* on the assumption that few or no other arms-control or inspection agreements will be implemented during the relevant period. This is not because we think this assumption is especially realistic, much less desirable, but because we think that as matters

* This chapter has benefited substantially from the comments and suggestions of many people. Since some of these prefer to remain anonymous, we shall not identify any of them, but the writers are much indebted to all of them.

now stand a test ban must be evaluated on its own merits, some of which include the possible effects on subsequent military cooperation.

THE CENTRAL STRATEGIC ISSUE *

Possible developments in nuclear weapons may be placed into two categories: the development of improved strategic weapons and development of improved tactical nuclear weapons for use on the battlefield. (Weapons for defensive purposes need not constitute a separate category.) The military evaluation of strategic-weapon developments and defensive developments will be treated in a later section of this chapter.

As with strategic weapons, the evaluation of possible developments in tactical nuclear weapons involves a consideration of what developments are possible and of the uses to which the tactical nuclear weapons can and should be put. The question, then, as to what role limited nuclear war should play in American military strategy is crucial in evaluating the desirability of a nuclear-test ban. In fact, much of the opposition to a test ban has been based on an erroneous evaluation of limited nuclear war. Most of the opponents of the test ban have argued that the United States must develop more efficient tactical nuclear weapons for use in limited war.

For example, Edward Teller [3] in a syndicated series of newspaper columns on the test ban has argued that the United States needs a capability of fighting a limited nuclear war. "It is to the interests of the Russians that we abstain from using [tactical] nuclear weapons. In the absence of such weapons . . . [Russian] tactics will work." He then goes on to deny that it is impossible to keep a limited nuclear war from exploding into an all-out war. This idea, that limited nuclear war is to the advantage of the United States, is echoed in a speech made in the Senate on May 12, 1960, by Senator Thomas J. Dodd [4] of Connecticut, entitled "The Eight Fallacies of the Nuclear Test Ban," in which he stresses the importance of developing clean nuclear weapons for tactical purposes and argues that this is the key to American supremacy in a limited war.

Few of the supporters of the nuclear-test ban have discussed this issue.† Most serious analyses of limited nuclear war, however, have concluded that it would not be to the advantage of the United States to use nuclear weapons in a limited war in which such weapons were used by both sides. Henry A. Kissinger, formerly a leading exponent of a limited nuclear war strategy, has substantially altered his views, as his chapter in the present volume indicates. For reasons given below, the writers of this chapter consider that limited nuclear war, as opposed to conventional war, might well be to the disadvantage of the United States, as well as being so

* For an extended analysis of the role of nuclear weapons in limited war and a discussion of the public debate on this issue, see reference 2.

† For an excellent exception see a Senate speech by Hubert Humphrey, in the *Congressional Record*, June 4, 1959.

theoretical possibilities (such as fusion involving tritium, lithium, and deuterium) are known to have theoretical upper-limit energy yields of about 25 to 30 KT/lb.*

Present-day thermonuclear bombs require a fission bomb to initiate the fusion reaction. Additional fission energy may be obtained by using the fusion reaction to induce the fission of natural uranium metal, which is much less expensive than U-235. The bulk of the radioactive fallout produced by a thermonuclear bomb is due to the fission yield, not to the fusion reaction. In current weapons, the fission yield may range from 5 per cent to 70 per cent or more of the total yield. Weapons having a low fission yield are sometimes termed "clean" bombs, since they produce relatively little radioactive fallout.

Ratios of Yield to Weight. The values given above for energy yield per unit weight relate only to the theoretical upper limit of energy yield and the weight of the material entering the nuclear reaction. In an actual military bomb, not all of the fissionable or fusionable material can react. In addition, a complete bomb or warhead includes a chemical high explosive, a detonation mechanism, safety devices, and a casing. Therefore, the actual yield per unit of weight of the complete bomb is considerably less than the values given above. Since the yield and weight of the total device are what count for military purposes, the yield/weight ratios of weapons are very important in describing their military effectiveness.

Such yield/weight ratios for several specific weapons have been estimated by Ralph Lapp [9] using Congressional testimony and other published sources of information. We are indebted to Lapp for the following estimates: the warhead weight for POLARIS and Minuteman (they use the same warhead) is about 600 pounds and has a yield of about 600 kilotons for a yield/weight ratio of 1 KT/lb. The Atlas ICBM has a warhead yield of about 4.5 or 5 megatons and has a yield/weight ratio of 1.5 KT/lb at present. Lapp estimates a current yield/weight ratio of 2 KT/lb for a more massive device of two-thirds fission yield, which would have more efficiency. (This would imply a total yield of 24 megatons for a 6-ton bomb. Since the B-52 has twice this bomb-carrying capacity,[10] the total B-52 bomb yield would be 48 megatons.)

These estimates agree generally with an independent estimate that can be deduced from a recent article by Hans Bethe: "If we want to increase the efficiency of our nuclear weapons by another factor of about 10 . . . from the presently achievable, we come to a point where the entire material in the weapon must undergo a nuclear reaction." [11] Since the theoretical fusion yields are in the region of 25 to 30 KT/lb, this indicates that present weapons must be about 3 KT/lb. Bethe further stated: "Since there must be assembly mechanism, triggers, bomb cases, and the like, this [increase

* Other reactions are, in some sense, possible in principle. As an extreme example, complete conversion of mass to energy according to the Einstein law $E = mc^2$ would yield 9 MT/lb. But such reactions are not thought to be feasible in weapons.

of efficiency by another factor of 10] is clearly impossible." In addition to the detonation mechanism and other nonreacting components, the fact that a bomb begins to explode before all the nuclear material has undergone reaction would further limit achievable yields. These data therefore indicate that current yield/weight ratios of large strategic weapons are in the region of 1 to 3 KT/lb, depending on weight, and that further testing and development might improve these ratios by a factor of 5.

It is important to understand that the possible improvement in efficiency is something like a factor of 5, not a factor of 500 or 5,000. For comparison, the efficiency of current bombs has been improved by about a factor of 1,000 over the Hiroshima and Nagasaki bombs, and by a factor of two or three million over chemical explosives. Quantitative considerations of this type are vital in evaluating the possible strategic significance of the further development of high-yield weapons.

If both we and the Soviet Union abstain from further improvements in efficiency, the situation will remain essentially as it is. If neither we nor the Soviets abstain from further testing, we both may increase the total deliverable yield by something like a factor of 5 (assuming that the delivery vehicles and systems remain fixed), or we may effect certain savings in the cost of delivery vehicles and systems (assuming that the total deliverable yield is held fixed), or there may be any combination of these two.* However, if we both pursue such developments, this will, broadly speaking, have no net effect on the relative military capabilities of the United States and the Soviet Union, though it might have some effect on the *stability* of the strategic balance. There are also some possible asymmetries. For example, if the Soviet Union wished to implement a counterforce doctrine and target their weapons against our hardened bases, while we wanted to implement a retaliatory doctrine with our weapons against Soviet population centers, then the symmetrical development of increased warhead yields could appear more valuable to the Soviets than to ourselves, since the increased yield would be of more significance for the counterforce posture. From the point of view of a United States analyst of strategy, the most important question is: How serious would it be if the Soviet Union achieved such improvements but we did not?

The writers believe that it would be serious enough to warrant some concern, but that this possibility is not an overriding consideration. The degree to which such potential clandestine developments could appear dangerous depends appreciably on the type of strategic posture the United States wishes to maintain. If we wish to maintain a clear-cut margin of strategic nuclear superiority, the potential costs of one-sided Soviet developments would be much greater than if we are willing to maintain a posture of approximate equality of strategic forces. As was indicated in chapter 1,

* The question of small mobile missiles (for invulnerability), or of defense missiles, which is often raised in this connection, is simply a special case of these two, and will be separately discussed below.

there has not been an explicit decision of national policy on this point at the time of writing, so far as we are aware. However, we believe—at least tentatively—that the posture of approximate equality is, on balance, to be preferred, and the tone of the discussion that follows is governed by this preference. A strong preference for a position of decisive superiority *could* make the possibility of one-sided Soviet improvements appear to be an overriding consideration.

It is necessary to rely to some extent on the tone of the discussion to convey our sense of the magnitude of the risk, because a more complete (and possibly more objective) analysis would require detailed consideration of several specific hypothetical weapon systems, and space does not permit this. A more thorough discussion would also disclose cases in which "yes or no" decisions about entire systems might hinge on the possibility of achieving developments of the type under consideration.*

Let us first assume that the Soviet Union used this increase in efficiency to increase their total deliverable yield by a factor of 5, assuming that the number and type of delivery vehicles remain fixed. Now, the area of blast damage of a warhead is proportional to the two-thirds power of the yield, and $5^{2/3}$ is approximately 3. Therefore, this development would be roughly equivalent to multiplying their missile and bomber forces by about a factor of 3.† As pointed out in the chapter above by Jerome B. Wiesner, we can (and probably will) build strategic-force systems that are effectively invulnerable (in the sense discussed by Wiesner) against forces that might be larger by a factor of 10 or more. Therefore, while we should not willingly give the Soviets a factor of 3 in strategic forces unless we achieved something of comparable advantage ourselves, it is at least possible to contemplate such clandestine Soviet developments with some equanimity, and it is also possible to think that there may be gains that would more than offset this possible risk. (As noted above, this possibility depends to some extent on strategic doctrine, and depends even more on the general levels of hostile forces and capabilities.)

The same conclusion follows in the event that the clandestine improvements in weapon efficiency were applied to reducing the cost of delivery vehicles and systems, while maintaining the total deliverable yield fixed. If other factors such as range and guidance are constant, the cost of a missile is roughly proportional to its payload. This would not mean, however, that the Soviets could reduce the cost of their total strategic system by a factor of 5, since the system involves much more than the missiles themselves. Other components include command, control, and communication systems; test facilities; launching-pad facilities (including submarines);

* Experts are likely to find the ensuing discussion too abstract; the writers apologize for this, but we see no short way of solving this problem.

† This assumes that the target system was not already saturated by the old forces. Against a target that can be destroyed with certainty by a 2 MT weapon of available accuracy, there is no point in going to 10 MT. Allowing an equivalent factor of 3 in total forces is therefore *very* generous.

and ground crews. All things considered, it does not seem likely that reducing warhead weight by a factor of 5 would reduce the cost of the system by more than a factor of 2.* The same considerations suggest that, if the Soviets wished to triple the effectiveness of their strategic forces, they could do it just as well by doubling their investment in the system as by improving warhead efficiency by a factor of 5, and this might possibly be cheaper than an extended program of clandestine tests conducted in outer space.

In this general problem one particular case is of sufficient importance to warrant discussing it as a specific example. It is often held that we need to develop small, mobile missiles as part of an invulnerable deterrent force, and it is sometimes held that a test ban would inhibit the development of lightweight warheads needed for such missiles and would therefore be destabilizing. Now, if it is argued that the POLARIS-Minuteman warhead (600 pounds) is too heavy for this purpose, and if a warhead of 200 pounds is desired, an extrapolation of the estimates given above suggests that current technology (without further testing) would enable the fabrication of 200-pound warheads with a yield of roughly 50 to 100 kilotons. The total deliverable yield could then be raised to virtually any value desired simply by multiplying the number of missiles. This is just a special case of the general principle discussed above.

In contradistinction to the argument that a test ban would be destabilizing because it would prevent the development of mobile missiles, it is sometimes held that the increased yield achievable by further testing would contribute to the counterforce capability of strategic weapons, which would be *destabilizing*. It is difficult, if not impossible, to see whether a test ban would, on balance, enhance or degrade the stability (in the usual narrow military sense) of strategic nuclear deterrence.

The foregoing discussion represents, we believe, a reasonable outlook on the situation to be expected. It is not meant to suggest that there are not special cases in which, for example, the advantage in cost might be more or less than a factor of 2—there are. But a special case that could reasonably be of decisive significance does not seem possible. We might be wrong about this. Other considerations discussed below should be understood as qualified in this same sense.

Pure Fusion Weapons. One development that might be obtained with the aid of further experimentation would be pure fusion weapons, that is, thermonuclear weapons that did not require a conventional fission bomb as a trigger and would require little or no fissionable material. The energy yield from such weapons would result entirely (or almost entirely) from nuclear-fusion reactions. These reactions are generally thought to require

* Of course, this depends on what one counts as part of the "system." If the "system" is taken to be the entire military establishment, a factor of 2 is far too large. A representative "system" might include a fleet of POLARIS submarines with their missiles, bases, and tenders, but would not include basic training centers, research and development centers, etc., in which case the factor of 2 would be vaguely right.

ignition temperatures achievable only with fission reactions, but some other means of ignition (detonation) might be found. The question of whether or not this development is likely to be achieved with further research and testing is quite controversial among weapon scientists, and the present writers have no basis for an independent judgment. However, it is possible to discuss a number of consequences that would follow if this development were achieved.

One of the original motives for pursuing the development of pure-fusion weapons was that such weapons would produce little or no radioactive fallout. In general, of course, this would make such weapons less hazardous to neutrals, allies, and ourselves. A less immediate consideration, on the other hand, is that the development of clean weapons might itself reduce the barriers to their use and thereby make it more likely. But the major issues hinge on more specific cases.

One motive for the development of "clean" weapons may be their use as defensive weapons, especially in the realm of air defense. It is obviously to our interest to minimize the fallout on our own territory or on that of our allies. Although it is rather difficult to assess the urgency of this motive, it does not appear to be overwhelming, since the damage produced by fallout from purely defensive weapons seems likely to be relatively small in absolute terms, and certain to be small in comparison to the damage produced by weapons used by the other side.*

The preceding paragraph should be considered in the light of the fact that thermonuclear devices now exist in which the fission yield is only 5 per cent of the total yield. However, such low-fallout weapons are probably not the most efficient as measured by yield/weight ratios.

Another reason sometimes advanced for the development of pure-fusion weapons is that they might be much cheaper than present nuclear weapons, for the fissionable material used in the latter is extremely expensive. For example, the cost of a pure-fission weapon of a few kilotons yield is in the region of a half million dollars, while a multimegaton thermonuclear weapon does not cost very much more. This indicates that the bulk of the cost of present thermonuclear weapons is probably associated with the fission trigger.

If we could produce pure-fusion weapons that required only relatively common materials such as lithium and did not require enormous production facilities, the cost of the large-scale production of nuclear weapons might be greatly reduced. It might then be possible to produce high-yield or low-yield weapons for, say, a few thousand dollars each (apart from the costs of development).

In the present state of the world, such a development would be inimical to the security of the United States, because it would permit any nation with even a modest industrial base to go a long way toward equalizing the

* This is especially true of weapons exploded at high altitudes (as for defense against aircraft or missiles), which produce negligible local fallout.

military power of the United States. The same consideration must appear just as forcefully to the Soviet Union. From the point of view of international security, we are already disturbed at the prospect of additional nations acquiring a few primitive fission bombs; we should be much more disturbed at the prospect of many nations acquiring a virtually unlimited stockpile of weapons of arbitrary yield. Since the development of simple and cheap fusion weapons has been pursued for several years without any visible sign of success, there is at least some reason to hope that, even if testing is resumed, such weapons will never be developed. If they ever are developed, it is virtually certain to prove impossible to keep the technology involved sufficiently secret.

From the point of view of the United States, the notion that the most wealthy nation on earth should encourage the development of weapon systems that provide "more bang for the buck" is the height of absurdity. Only a certain amount of "bang" is required to dominate or destroy any given military objective. Therefore, the development of systems providing "more bang for the buck" means that nations with many fewer "bucks" can equalize our military power with respect to the target systems of the type involved. We have already seen this phenomenon with respect to present-day nuclear weapons; the Soviet Union, which has a comparable population and a considerably inferior industrial base, has virtually equalized the military power of the United States with respect to certain types of nuclear conflicts. The development of cheap and simple fusion weapons would enable many nations to move in this direction.

It may not be entirely up to us to decide whether or not such weapons shall be developed. Although the Soviet interest in abstaining from this development would appear to be at least as large as our own, it is important to ask: How seriously (if at all) would the military position of the United States relative to the Soviet Union be degraded, if the Soviets achieved this development (by clandestine testing or otherwise) but if we did not? The answer, while complicated, appears to be that the threat would be manageable.

The first problem is whether our present stockpile of weapons is sufficient for any possible conflict, or whether we ourselves should need a greatly increased supply of weapons to offset the possibility of a large-scale Soviet production of cheap fusion weapons *per se*. A recently reported estimate [12] placed the current United States production of U-235 at about 70,000 kilograms (150,000 pounds) per year. It was not stated how long production rates have been at this level, but the current rate suggests that estimates of 600,000 to 1,000,000 pounds for the total production through the end of 1960 of U-235 would be a reasonable range. If we use the million-pound figure, and assume that this can be detonated with current techniques at 20 per cent efficiency (mass fissioned to mass fissionable), or about 2 KT/lb, this stockpile would imply a total available *fission* yield from U-235 of 2,000,000 kilotons, or 2,000 megatons. We do not know

how this is fabricated into stockpiled weapons, but we can look at some possibilities. To begin with, if this were all fabricated into large thermonuclear weapons of 5 per cent fission yield, this would imply a total yield capability of 40,000 megatons. If we assume that 5 per cent represents the yield of the fission trigger and that additional yield can be obtained by using the fusion reaction to fission natural uranium metal (i.e., U-238, as opposed to U-235), this could imply a total weapon stockpile of about 80,000 megatons with a 50 per cent fission yield; for example, 10,000 bombs of 8 megatons each. These would be sufficient, if delivered, to obliterate the Soviet Union and China together. If all of the U-235 stockpile were fabricated into tactical fission weapons, each using 20 pounds, it would provide 50,000 tactical weapons of 40 kilotons (or less) each. What is more likely than any one of these possibilities is some mixture of them, for example, a total of 25,000 tactical weapons and a collection of large strategic weapons having a total yield of perhaps 30,000 to 40,000 megatons.

It is easy to show that a total of 2,000 tactical weapons of a few kilotons' yield is certainly sufficient to destroy completely a very large field army of 25 line divisions, even if we assume any practical degree of dispersion of the forces. In practice, a much smaller number of bombs would probably suffice. Therefore, even if we allow several thousand weapons for air defense or antisubmarine purposes, and a stockpile of strategic weapons of obliterating proportions, it is quite clear that we shall not have an urgent need of multiplying our possible weapon stockpiles by anything like a factor of 5 or 10. This fact is virtually independent of Soviet weapon stockpiles *per se*. In other words, even if the Soviets did develop cheap fusion weapons while we did not, they would not gain an overwhelming military advantage from this fact alone.

The problem becomes more complicated if it is assumed that the Soviets also might develop new delivery systems and tactics to accompany the cheap fusion weapons, and then deployed the resulting weapon systems in a large-scale manner. Possibilities of this kind include, for example, novel types of air defense systems, capabilities for antisubmarine warfare, and a new spectrum of infantry weapons and tactics. Large-scale Soviet achievements of this type, if unmatched by corresponding developments in the United States, could be genuinely hazardous. So long as the Soviet developments remained clandestine, they would not of themselves provide the Soviets with additional political influence or bargaining power. However, they might well tempt the Soviets to aggressive or even reckless courses of action. And if deterrence failed, in consequence of Soviet aggressiveness, the United States might then be at a considerable disadvantage in the conduct of the resulting war.

This problem should not be minimized. On the other hand, it should be emphasized that Soviet achievements on the scale necessary for a decisive effect are most unlikely to remain completely invisible. In order to utilize cheap fusion weapons in a significant way, the production and deployment

of tens or hundreds of thousands of weapons and weapon systems would be required, as would the training of tens or hundreds of thousands of troops. Out of many thousands of possibilities, a single informed defector is not at all unlikely. Even without an overt defection, activity on the required scale should be readily detectable by the Central Intelligence Agency, especially if the Agency is actively "looking" for such activity. In view of this fact, plus certain other considerations to be summarized in the next paragraph, the possibility of clandestine development by the Soviets of cheap fusion weapons does not presently seem to be an unacceptable risk.

In outline, the major considerations bearing on this problem appear to us as follows: (1) The possible development of cheap fusion weapons is an uncertain matter; (2) If achieved, the mere multiplication of weapon stocks would not itself be particularly hazardous; (3) The development could be hazardous if accompanied by the development and large-scale deployment of new weapon systems and tactics; (4) However, the accomplishment of (3) would constitute a major activity extending over several years and involving many thousands of people; (5) It is probable that such activity would be detected in sufficient time to take whatever remedial measures would have been possible in the absence of a test ban. In connection with this last point, we believe it important for the United States to maintain a strong laboratory research and development program on cheap fusion weapons, together with paper studies and "war games" on the possible utilization of such weapons, as a means of keeping abreast of the possibilities. This program might even extend to the prototype production of such (untested) weapons if laboratory studies and designs should eventually appear workable (or if such "success" has happened already).

Refined Tactical Weapons. So far as acceptance by the United States is concerned, it appears to us that the most delicate issues involved in the test-ban controversy are likely to be those surrounding the further development of tactical nuclear weapons. This is partly because the detection of clandestine tests of low-yield tactical weapons is most uncertain, and partly because of the widespread misunderstanding, and some degree of genuine uncertainty, as to what limited nuclear war is. There is a nearly complete coincidence between people who favor a limited nuclear war strategy for the United States and people who are opposed to a complete test ban without "adequate" inspection.

The extent to which further improvements in tactical weapons are possible is a matter of some controversy among weapon scientists. Some hold that we already have almost everything that might be desired for tactical weapons, as to size, weights, yield, etc. Others hold that this is not the case and that further developments are likely to prove very important. This apparent division of opinion actually rests on the issue of a limited nuclear war, for the purely technical facts involved seem less in dispute. It seems likely that further improvements in yield/weight ratios of tactical weapons are possible, perhaps something like the factor of 5 discussed

above. Additional flexibility in the physical shape of tactical weapons would also be a likely development, as would the development of weapons of very low yield (e.g., 1 ton). The possible development of pure fusion weapons for tactical purposes, while controversial, is at least conceivable. Finally, a special type of tactical weapon, called a neutron bomb, might be developed. According to Senator Dodd, in a Senate speech of May 12, 1960, a neutron bomb "can theoretically be produced by tailoring the energy of a fusion explosion so that, instead of heat and blast, its primary product is a burst of neutrons. Such a burst would do negligible physical damage, but it would immediately destroy all life in the target area." [4] Evidently such a bomb would be purely an antipersonnel weapon. There has been little public discussion of neutron bombs, and it is not known whether the likelihood of their development is controversial, but we are willing to assume for the time being that the weapon can be developed with further testing.

The question then arises as to what the strategic significance of this development would be. If we are to use nuclear weapons at all, we should prefer to use weapons that produced the least in undesirable side effects, such as unwanted damage to property. However, it is equally clear that the avoidance of unnecessary damage is of negligible importance from a purely *military* point of view, and in particular is unlikely to affect the purely military outcome. The same statement appears to be true of other possible developments in tactical weapons, such as reduced weight or improved weapon shapes. As noted above, a very large field army can be completely saturated with a few thousand weapons. We have the weapons and the delivery systems to do this, and, if we were engaged in a limited nuclear war with the Soviets, whether we could do it or not is likely to depend much more on whether we have sufficient target intelligence as to the disposition of their forces than on whether their weapons are one-fifth as heavy or twice as heavy as ours. This fact, it should be emphasized, is no less true in reverse; the Soviets are perhaps equally indifferent to factors of 2 or 5 in the relative weights (or yields) of our respective tactical weapons.

The sharpest way of stating this argument is to observe that a *military* counter to the possibility of clandestine Soviet development of small tactical weapons is a willingness to "escalate" the level of conflict in the event that unexpected weapons are introduced by the other side. Although the present writers are not in most cases sympathetic to the nuclear escalation of limited wars, the relatively low likelihood that it would be required for this purpose combines with the relatively modest degree of escalation necessary if it were required to make the risks of this strategy seem acceptable in comparison to the alternative (of resuming testing at the present time). Where other considerations (such as this one) are not dominant, we should argue that it is important to maintain approximately the same spectrum of capabilities as that that might reasonably be possessed by prospective opponents.

It is worth stressing that our argument assumes that a limited nuclear war would be quite different in character from a conventional war. We should otherwise feel obliged to conclude that the military outcome of a limited nuclear war might very well be sensitive to a factor of 5 in comparative yield/weight ratios of weapons. (The military outcome of a nonnuclear war would probably be very sensitive to a factor of 5 in fire power.) In this respect, we differ from some of our friends who argue that the test-ban issue can be fought out on the basis of the "sufficiency" or "insufficiency" of our present weapons without any reference to the character of a limited nuclear war. But both the present writers have devoted considerable study, separately and jointly, to the problems of limited nuclear war, and we do not believe that it would resemble the conduct of a conventional war. In view of the probable character of a limited nuclear war, we do not believe that a further factor of 5 (or more) would be militarily significant, whether achieved by both sides, neither side, or one side only.*

Whether this conclusion is accepted or not, we believe that the debate would in any event be greatly improved if the participants would argue the specific issues of their images of the probable conduct of a limited nuclear war. In view of the fact that we have lived for fifteen years in the nuclear age and that no sensible doctrine for the tactical employment of nuclear weapons has yet been devised, a considerable burden would thereby fall on the advocates of a limited nuclear strategy; but we believe this same fact shows that the burden of proof should fall on them.

Testing for Weapon Effects. Some military tests involving the detonation of nuclear weapons are intended to yield information about weapon effects, not developmental information about the weapons themselves. Such information includes blast, heat, and radiation effects on various types of structures and mechanisms; patterns of fallout distributions; certain upper-atmosphere phenomena; and effects on the propagation of electromagnetic waves from radar and communication systems. In contrast to certain weapon development tests that might be conducted underground or in outer space without detection, most significant tests for weapon effects would take place in or near the atmosphere and would be easily detectable. Therefore, the principal cases to be considered are those in which both sides abstain or neither side abstains; clandestine cheating to determine weapon effects is not generally feasible. (There may be one or two significant exceptions.)

One of the major areas for testing of this type is in testing the vulnerability of "hardened" weapon systems. Some of our missiles (and related components of strategic weapon systems) will be protected against blast and radiation damage by concrete silos and bunkers and by being placed partly or wholly underground. These structures are designed to withstand a certain blast overpressure, such as 100 pounds per square inch, and a certain level of radioactive contamination. In other words, it is thought that an enemy

* This applies also to possible types of limited nuclear war of a more sophisticated variety than that discussed above.

warhead of a given yield would have to be closer than a certain distance (depending on the yield) in order to render the system inoperative. For the most part, such systems have not been tested by actual nuclear explosions. It is not known, therefore, whether they are slightly or considerably better than the (conservative) theoretical design values, or whether they might have hidden defects that would only be disclosed by an actual attack. But this uncertainty cuts both ways; the Soviet planner of an attack would be concerned that the structures might be very much better than the nominal design values, while we would be concerned about the possibility of unforeseen defects. This uncertainty may well be more deterring to a would-be attacker than would precise knowledge of the vulnerability of the targets he wishes to attack. Therefore, it appears to be about as much to our interest that both we and the Soviets should abstain from such testing as that we should both pursue experiments of this type. (This depends to some extent on which types of strategic problems seem most worrisome.) This same fact appears true of most other types of testing for weapon effects, for example, testing the vulnerability of underwater objects such as submarines.

However, one area of testing weapon effects that may not have this character involves the vulnerability of communication systems. It is obviously in our interest to retain control over our strategic forces in the event of a war; it may be less obvious but probably no less true that it is equally in our interest that the Soviets should also retain control over their forces, at least until their weapons were either exhausted or destroyed. This is because if there were a general nuclear war, they might be persuaded at some point to stop firing at us or they might decide to fire only in limited ways, and it would be important that they should be able to implement such decisions. For similar reasons, it might be important to the Soviets that we should remain in control of our forces. In both cases, this question hinges on operational doctrine and war plans. If the enemy plans call for the independent firing of all weapons if the central communication system is disrupted, we do *not* wish to destroy their control system. But there are potential hazards to existing communication systems from uncertain weapon effects.

To begin with, there is a problem of the vulnerability to blast of facilities such as transmitter installations and underground cables. However, problems of this type are better understood and fairly predictable. What are less predictable, and potentially more important, are certain weapon effects that influence the propagation of radio waves. Two weapons in the megaton range were detonated at high altitudes in the Pacific in the summer of 1958, and were observed to disturb some communication transmissions throughout an area of at least 1,500 miles in radius.[18] The phenomena involved are probably not entirely understood, and the development of adequate communication systems might possibly be facilitated by further experiments of this type. (However, such experimental information might

be destabilizing.) This is therefore one area in which it might be to the interest of both the Soviets and ourselves to pursue further testing, if it were not for other considerations. It seems likely that the communication problem can be adequately solved by other means, but it is worth pointing out that a reduced vulnerability of communication and control systems might mitigate the consequences of a war.

Antimissile Weapons. The problem of warheads for antimissile missiles is mentioned so often by opponents of a test ban that the subject deserves some comment, though it has often been much overrated. The major problem of an antimissile missile has nothing to do with warheads, and if this major problem can be solved, the further development of warheads is not critical, although budgets may be affected.

The major problem in question is that of discriminating by radar (or other) techniques between an actual incoming warhead and target decoys sent along with the warhead. This problem is so formidable that many experts feel that the terminal-phase interception of enemy missile warheads at sufficiently high altitudes to protect cities will never be practicable, although low-attitude interception to protect "hardened" retaliatory forces may be more so. If this problem of discrimination and others relating to the guidance of the interception vehicle can be solved, the problem of a suitable warhead can also be solved, with or without further testing. The principal effect of further testing might be the projected improvement in yield/weight ratios discussed above. Again, a reduction in warhead weight by a factor of 5 might result in a reduction in system cost by something like a factor of 2, or perhaps even less in this case because of the necessary large investment in radar systems. The practicability of a system of this type, for either the United States or the Soviet Union or both, is not likely to stand or fall on a factor of 2 in the system cost. The present Nike-Zeus program in the United States is presumably proceeding on the basis of current warhead technology.*

Two other problems relating to this warhead development deserve brief mention. First, it seems unlikely that a specific warhead design for the Nike-Zeus missile has been tested. Any warhead eventually employed should, in our view, therefore be based on existing designs. This would not mean, however, that the weapon would be unreliable without an actual test; we would infer this fact if for no other reason than that leading weapon scientists who are opposed to a test ban never mention this problem. In addition, the total number of weapon tests conducted to date (100-odd), when coupled with Bethe's statement[11] that we have "an enormous arsenal of . . . weapons" and Teller's statement in his chapter of this book that "each nuclear explosion is . . . an experiment whose outcome is very much in doubt," clearly indicates that we have many operational weapons that have

* As noted above in an earlier footnote, there is little motivation to develop low-fallout weapons for this application because they would be exploded at high altitudes, and would therefore produce negligible local fallout.

References

Editor's Preface

1. Louis Henkin, *Arms Control and Inspection in American Law* (New York: Columbia University Press, 1958).

1. Setting and Goals of Arms Control
DONALD G. BRENNAN

1. Arnold Wolfers and others, *Developments in Military Technology and Their Impact on United States Strategy and Foreign Policy*. Study No. 8 prepared at the request of the Committee on Foreign Relations of the United States Senate (Washington, D.C.: United States Government Printing Office, 1959).
2. William W. Kaufmann (ed.), *Military Policy and National Security* (Princeton: Princeton University Press, 1956).
3. Henry A. Kissinger, *Nuclear Weapons and Foreign Policy* (New York: Harper, 1957).
4. Bernard Brodie, *Strategy in the Missile Age* (Princeton: Princeton University Press, 1959).
5. Klaus Knorr (ed.), *NATO and American Security* (Princeton: Princeton University Press, 1959).
6. Oskar Morgenstern, *The Question of National Defense* (New York: Random House, 1959).
7. Thomas C. Schelling, *The Strategy of Conflict* (Cambridge: Harvard University Press, 1960).
8. Henry Rowen, *National Security and the American Economy in the 1960's*. Study paper No. 18 prepared for the Joint Economic Committee, Congress of the United States (Washington, D.C.: United States Government Printing Office, 1960).
9. Herman Kahn, *On Thermonuclear War* (Princeton: Princeton University Press, 1960).
10. Henry A. Kissinger, *The Necessity for Choice: Prospects for American Foreign Policy* (New York: Harper, 1960).
11. Raymond L. Garthoff, *Soviet Strategy in the Nuclear Age* (New York: Frederick A. Praeger, 1958).
12. H. S. Dinerstein, *War and the Soviet Union* (New York: Frederick A. Praeger, 1959).
13. Thomas C. Schelling, "The Retarded Science of International Strategy," *Bulletin of the Atomic Scientists* (March 1960), *16*: 103–106.
14. ———, "Bargaining, Communication, and Limited War," *Conflict Resolution* (1957), *1*: 19–36.
15. ———, *Nuclear Weapons and Limited War* (RAND Corporation Report P-1620), February 20, 1959.
16. Herman Kahn, *The Nature and Feasibility of War and Deterrence* (RAND Corporation Report P-1888-RC), January, 20, 1960.

17. Albert Wohlstetter, "The Delicate Balance of Terror," *Foreign Affairs* (January 1959), 211–234.

18. John B. Phelps, Raymond Foye, and Daniel Howland, *Some Calculations on Counterforce Strategies in a General Nuclear War* (The Mershon National Security Program, Ohio State University, Columbus [referred to below as *Mershon*], Report RP-1), August 27, 1959.

19. Raymond Foye and John B. Phelps, *Counterforce Calculations: Attack and Retaliation with Mixed Weapons Systems* (Mershon Report RP-2), November 24, 1959.

20. S. M. Rosow and John B. Phelps, *Measures of Destruction: Some Observations on Damage Levels in a General Nuclear War* (Mershon Report RP-3), December 14, 1959.

21. John B. Phelps and Raymond Foye, *A Technique for Fallout Casualty Calculations* (Mershon Report RP-5), January 22, 1960.

22. Samuel Glasstone (ed.), *The Effects of Nuclear Weapons* (Washington, D.C.: United States Government Printing Office, 1957), p. 505.

23. Joint Committee on Atomic Energy, Congress of the United States, *Summary Analysis of Hearings on Biological and Environmental Effects of Nuclear War* (Washington, D.C.: United States Government Printing Office, 1959).

24. Herman Kahn and others, *Report of a Study of Non-Military Defense* (RAND Corporation Report R-322-RC), July 1, 1958.

25. T. C. Schelling, *Surprise Attack and Disarmament* (RAND Corporation Report P-1574), December 10, 1958. (Published in Knorr,[5] also in abridged form in *Bulletin of the Atomic Scientists* (December 1959), *15*:413.)

26. ———, "Proposal for a Special Surveillance Force," *World Politics* (October 1960), *13*: 1–18.

27. United Nations General Assembly, *Report of the Conference of Experts for the Study of Possible Measures Which Might be Helpful in Preventing Surprise Attack and for the Preparation of a Report Thereon to Governments* (United Nations Document A/4078-S/4145, 5 January 1959).

5. The Arms Race and Some of Its Hazards

HERMAN KAHN

1. The *New York Times*, April 22, 1958.

2. Peter Bryant, *Red Alert* (New York: Ace Books, 1958).

3. Bertrand Russell, *Common Sense and Nuclear Warfare* (New York: Simon and Schuster, 1959).

4. T. C. Schelling, *The Strategy of Conflict* (Cambridge: Harvard University Press, 1960).

5. The term seems to be due to Amrom Katz.

6. While I would not care to guess the exact form an efficient Doomsday Machine would take, I would be willing to conjecture that if the project were started today and were sufficiently supported, one could have such a machine (or close approximation to such a device) by 1970. I would also guess that the cost would be between ten and a hundred billion dollars. Even then it might not be possible to destroy groups of especially well-prepared people. The mechanism one would use would most likely involve, not the breaking up of the

earth, but the creation of really large amounts of radioactivity, or the causing of major climatic changes.

7. I should make the point, though, that contrary to many common statements, current (1961) weapon systems are not Doomsday Machines or even close to being such devices.

8. This is actually an extreme view of the German situation. During most of the period 1933–1944 Hitler was restrained by "responsible" elements, and many of his gambles were actually hedged. On many occasions on which he seemed too reckless, military groups prepared a *coup d'état* should he go too far.

9. It is more feasible to survive and recuperate from a war than is generally thought. RAND Report R-322-RC, *Report on a Study of Non-Military Defense,* June 1958, has a description of the possibilities.

10. Testimony of General LeMay before the 1956 Subcommittee on the Air Force, Senate Armed Services Committee, p. 135.

11. See Fred C. Iklé, *Nth Countries and Disarmament* (RAND Corporation Report P-1956), April 1960, for further discussion of this important problem.

12. An international agency with a near-monopoly for force might come from any of the following possibilities, listed in order of apparent probability rather than desirability: (1) a Soviet- or United States-dominated world arising most likely out of war; (2) some other results of a war; (3) a Soviet Union–United States combination which is in effect a world government, though it may not be openly called so; (4) some of the NATO nations and China added to the above combination as influential, if not equal partners; (5) the haves against the have-nots, probably without exploitation, and, perhaps, with aid to underdeveloped nations, but with stringent arms control in which authority and responsibility are roughly proportioned to military and economic development; (6) a sort of world federal state in which power is proportioned to sovereignty and population, as in the United States Congress.

While many of the above possibilities may strike most readers as unpleasant or undesirable, it is quite possible that even a "bad" world government is preferable to an accelerated and uncontrolled arms race. It is to be hoped this last will not be the only choice available.

7. Limited War: Conventional or Nuclear? A Reappraisal

HENRY A. KISSINGER

1. For a fuller discussion of limited nuclear war, see the author's *Nuclear Weapons and Foreign Policy* (New York: Harper, 1957), chap. VI, "Problems of Limited Nuclear War," pp. 191 ff.

2. *Ibid.*, pp. 174 ff.

8. Economic Implications of Arms Control

KENNETH E. BOULDING

1. The recent literature on this subject is almost entirely confined to pamphlets and journals; there is a startling absence of formal or academic studies.

Many of the peace groups have published pamphlets relating to the economics of disarmament: see, for instance, *If the Arms Race Ends* (two papers by Albert L. Gray, Jr., and Byron L. Johnson, Board of World Peace of the Methodist Church, 740 Rush Street, Chicago 11, Illinois); *Fact Sheet: Economic Consequences of Disarmament* (Committee for World Development and Disarmament, United Nations Plaza, New York, October 1959); see also publications by the Friends Committee on National Legislation, 245 Second Street N.E., Washington 2, D.C., and by the Women's International League for Peace and Freedom, 2006 Walnut Street, Philadelphia 3, Pennsylvania.

Some of the more "neutral" policy research groups have also published pamphlets: the National Planning Association (1606 New Hampshire Avenue N.W., Washington, D.C.), Joint Statement, *Can the American Economy Adjust to Arms Reduction* (January 4, 1960); and the Committee for Economic Development (711 Fifth Avenue, New York 22, New York), *The Defense We Can Afford,* by James F. Brownlee. The Senate Subcommittee on Disarmament of the United States Senate Committee on Foreign Relations published *Hearings* (1957), of which Parts 8, 9, and 13 are particularly relevant.

Periodical and newspaper articles include: Emile Benoit, "Will Defense Cuts Hurt Business," *Michigan Business Review,* March 1957; Seymour Harris, "The Economics of Disarmament," *Current History,* October 1957; "Can We Prosper Without Arms," *New York Times Magazine,* November 8, 1959; and Senator Hubert H. Humphrey, "After Disarmament—What?" *Think,* January 1960. *The Nation* had a special issue, "Economic Hazards of Arms Reduction," March 28, 1959.

9. Reciprocal Measures for Arms Stabilization

THOMAS C. SCHELLING

1. See T. C. Schelling, "Surprise Attack and Disarmament," in Klaus Knorr (ed.), *NATO and American Security* (Princeton: Princeton University Press, 1959), or the shorter version in T. C. Schelling, *The Strategy of Conflict* (Cambridge: Harvard University Press, 1960), chap. 10.

2. For an extensive study of tacit bargaining, with special reference to limited war, see T. C. Schelling, *The Strategy of Conflict* (Cambridge: Harvard University Press, 1960), chaps. 3 and 4 and Appendix A.

3. A more extensive discussion of this point appears in T. C. Schelling, "Arms Control: Proposal for a Special Surveillance Force," *World Politics,* October 1960.

10. The Case for Unilateral Disarmament

ERICH FROMM

1. Charles E. Osgood, "Suggestions for Winning the Real War with Communism," *Conflict Resolution* (December 1959) *3:* 131, and also "A Case for Graduated Unilateral Disarmament," *Bulletin of Atomic Scientists* (1960), *16:* 127 ff.

2. This condition is in my opinion to be taken only as an optimal *desidera-*

tum, since any weakening of one power's aggressive potential means strategically some increase in the opponent's aggressive potential.

3. Charles E. Osgood, *op. cit.*, p. 316.

4. Bertrand Russell, *Common Sense and Nuclear Warfare* (London: G. Allen & Unwin, 1959). Stephen King-Hall, *Defense in the Nuclear Age* (Nyack, N.Y.: Fellowship Publications, 1959). Jerome Davis and General H. B. Hester, *On the Brink* (New York: Lyle Stuart, 1959). Lewis Mumford, *The Human Way Out* (Pendell Hill Pamphlet No. 97, 1958). C. W. Mills, *The Causes of World War Three* (New York: Simon & Schuster, 1959). George F. Kennan, "Foreign Policy and Christian Conscience," *Atlantic Monthly,* May 1959. Richard B. Gregg, *The Power of Nonviolence* (Nyack, N.Y.: Fellowship Publications, 1959). American Friends Service Committee, *Speak Truth to Power, Quaker Search for an Alternative to Balance* (1955).

5. George F. Kennan, *op. cit.*, pp. 44 ff.

6. This premise is shared by the report of the National Planning Association of America: *1970 without Arms Control; Implications of Modern Weapons Technology* (by NPA Special Project Committee on Security through Arms Control, Planning Pamphlet No. 104, May 1958, Washington, D.C.), which states: "Not only does the danger of war remain a possibility, but the probability totalled over time increases, becoming a certainty if sufficient time elapses without succeeding in finding alternatives." Or, E. Finley Carter, President of the Stanford Research Institute, writes: "In the search for security through the application of technology to weapons for destruction, the Soviet bloc and the Western allies have created a mortal common enemy—the threat of accidental nuclear war" (*SRI Journal,* Stanford Research Institute, Fourth Quarter 1959, *3*: 198). Herman Kahn also concludes, "It is most unlikely that the world can live with an uncontrolled arms race lasting for several decades" (*ibid.*, p. 139). He emphasizes that it is unrealistic to believe that war has become impossible because of its extremely destructive character.

The advisor on Science and Technology of the Democratic Advisory Council of December 27, 1959 declared: "All-out nuclear war seems not only possible but probable as long as we pursue our present military policies and fail to achieve international agreements of broad scope designed to alleviate this unstable situation. The triggering of a nuclear war by mistake, by misadventure or by miscalculation is a constant danger." It must be stressed that the danger lies not only in technical errors, but equally in the blundering decision-making by political and military leaders. If one remembers the political and military blunders committed by many of the leaders in the conduct of wars of 1914 and 1939, it is not difficult to visualize that, given present-day weapons, the same type of leaders will blow the world to pieces, in spite of good intentions.

7. For a detailed analysis of modern society cf. my *The Sane Society* (New York: Rinehart and Co., 1955).

8. *SRI Journal* (1959), *3*: 140.

9. For the very same reasons, there is a real chance for the future abolition of war, a chance which never existed in the past. In most of man's history, the improvement of his material situation required an increase in human energy (slaves), additional land for cattle raising or agriculture, or new sources of raw materials. The techniques of the present and of the future will permit an

increase in material wealth by an increased industrial and—indirectly—agricultural productivity, without the need of enslaving or robbing others. At present and in the future, war would have as its only "rationale" the irrationality of human desire for power and conquest.

10. Whether or not political leaders are sane is not a matter of historical accident. Any government which has set out to do the impossible—for instance, to achieve equality and justice when the requisite material conditions are lacking—will produce fanatical and irrational leaders. This was the case with Robespierre, as it was with Stalin. Or, a government which tries to reconcile the interests of the most backward social class (the lower middle class) with those of the economically progressive classes (workers and businessmen) as the Nazi government did, again will produce fanatical and irrational leaders. The Soviet Union today is on the road toward solving its economic problems successfully; hence it is not surprising that her leaders are realistic men of common sense.

11. *Op. cit.*, pp. 52, 65.

12. Peter B. Young, "The Renunciationists," *Airpower*, the Air Force Historical Foundation, *7*, 1: 33.

13. *Ibid.*

14. Herman Kahn, *Report on a Study of Non-Military Defense* (RAND Corporation Report R-322-RC, July 1, 1958), p. 13.

15. *Ibid.*

16. General de Gaulle, in a speech in April 1960.

11. Comprehensive Arms-Limitation Systems

JEROME B. WIESNER

1. Submission to the United Nations Disarmament Commission, April 24, 1952.

2. Louis B. Sohn, "Territorial Disarmament," a private memorandum, November 2, 1959.

3. Leo Szilard, "How to Live with the Bomb and Survive," *Bulletin of the Atomic Scientists* (1960), *16*: 58.

4. Philip Noel-Baker, *The Arms Race* (London: Stephens and Sons, 1958).

12. Policy Considerations of a Nuclear-Test Ban

DONALD G. BRENNAN AND MORTON H. HALPERIN

1. United States Senate Subcommittee on Disarmament, *Conference on the Discontinuance of Nuclear Weapons Testing. Analysis of Progress and Positions of the Participating Parties* (October 1958-August 1960; October 1960).

2. Morton H. Halperin, "Nuclear Weapons and Limited War," mimeographed, Harvard Center for International Affairs, 1960 (forthcoming in *The Journal of Conflict Resolution*).

3. The series appeared in The Washington *Post and Times Herald*, August 1960, as well as in a number of other papers.

4. Thomas J. Dodd, "The Eight Fallacies of the Nuclear Test Ban," *Congressional Record*, May 12, 1960.

5. Hanson Baldwin, "Limited War," *The Atlantic* (May 1959), pp. 35–43. Bernard Brodie, *Strategy in the Missile Age* (Princeton: Princeton University Press, 1960), pp. 319–335. William W. Kaufmann, "The Crisis in Military Affairs," *World Politics* (1958), *10*: 507–603. James King, "Nuclear Plenty and Limited War," *Foreign Affairs* (1957), *35*: 238–256. Robert Osgood, "Stabilizing the Military Environment," *American Political Science Review* (March 1961), *55*:24–39 (footnote, p. 28). Henry Rowen, "National Security and the American Economy in the 1960's" (Joint Economic Committee, Study Paper No. 18), January 30, 1960, pp. 45–48. Thomas C. Schelling, *Nuclear Weapons and Limited War* (RAND Corporation Report P-1620), February 20, 1959. Albert Wohlstetter, *The Delicate Balance of Terror* (RAND Corporation Report P-1472), December 1958, pp. 33–36. P. M. S. Blackett, "Thoughts on British Defence Policy," *The New Statesman* (1959), *58*:783. Also, private communications from Herman Kahn and Arthur Hadley, 1960.

6. Fred C. Iklé, "Nth Countries and Disarmament," *Bulletin of the Atomic Scientists* (December 1960), *16*:391–394.

7. National Planning Association, *The Nth Country Problem and Arms Control* (Planning Pamphlet No. 108), January 1960.

8. *Aviation Week* (October 17, 1960), p. 25.

9. Private communication, October 1960.

10. Jane's, *All the World's Aircraft 1957–1958* (New York: McGraw-Hill, 1958).

11. Hans A. Bethe, "The Case for Ending Nuclear Tests," *The Atlantic* (August 1960), pp. 43–51. Reprinted in *Survival 2* (September-October 1960), pp. 179–188.

12. *Nucleonics* (September 1960), p. 18.

13. "Results of the Teak and Orange Shots in the 1958 Hardtack Series" (reprinted in reference 14 below, pp. 865–932).

14. Joint Committee on Atomic Energy, *Hearings,* "Technical Aspects of Detection and Inspection Controls of the Nuclear Weapons Test Ban" (2 parts), April 1960.

14. The Inclusion of Communist China in an Arms-Control Program

A. DOAK BARNETT

1. *Current Affairs Handbook* (Peking, Vol. 1, No. 2), November 5, 1950; *Current Background* (American Consulate-General, Hong Kong, No. 32), November 29, 1950, p. 10.

2. K. M. Panikkar, *In Two Chinas* (London: G. Allen and Unwin, 1955), p. 108.

3. George A. Modelski, *Atomic Energy in the Communist Bloc* (Melbourne: Melbourne University Press, 1959), p. 186.

4. See *NCNA* (*New China News Agency*), October 12, 1954; *SCMP* (*Survey of the China Mainland Press,* American Consulate-General, Hong Kong) 906, October 12, 1954, p. 6.

5. Communique of the U.S.S.R. Council of Ministers, *Tass,* January 17, 1955, in Modelski, *op. cit.,* p. 125.

6. See *NCNA,* April 30, 1955; *SCMP* 1038, April 30-May 2, 1955, p. 16.

7. *People's Daily* (Peking), June 12, 1955, in Modelski, *op. cit.*, p. 187.

8. *NCNA*, January 29, 1956, in Modelski, *op. cit.*, p. 187.

9. *Ibid.*, p. 186.

10. Nieh Jung-chen, "China's Progress in Science and Technology in Ten Years," *People's Daily*, September 27, 1959; *Current Background* (No. 608), January 8, 1960, p. 4.

11. Ch'ien San-ch'iang, "China Marches Forward in Big Strides in Regard to the Peaceful Use of Atomic Energy," *People's Daily*, October 11, 1959; *Current Background* (No. 608), January 8, 1960, p. 13.

12. Nieh, *op. cit.*, p. 8.

13. Ch'ien, *op. cit.*, p. 13.

14. *Ibid.*, p. 14.

15. *Die Welt* (Hamburg), May 12, 1958.

16. *Stuttgarter Zeitung*, May 12, 1958.

17. *NCNA*, May 16, 1958; *SCMP* 1777, May 22, 1958, p. 28.

18. *Chieh Fang Chün Pao*, May 23, 1958; *SCMP* 1900, November 24, 1958, p. 9. See also Washington *Post and Times Herald*, July 19, 1959.

19. *Unita* (Rome), July 1, 1959. See also Washington *Post and Times Herald*, July 19, 1959.

20. See, for example, the *New York Times*, August 18, 1958.

21. *Pravda*, August 31, 1958; *Current Digest of the Soviet Press* (Vol. 10, No. 35), October 8, 1958, p. 17.

22. *Pravda*, September 5, 1958; *Current Digest of the Soviet Press* (Vol. 10, No. 36), October 15, 1958, p. 9.

23. *New York Times*, September 9, 1958.

24. *New York Times*, September 20, 1958.

25. *People's Daily*, September 21, 1958; *SCMP* 1860, September 24, 1958, p. 48.

26. *Pravda*, October 6, 1958; *Current Digest of the Soviet Press* (Vol. 10, No. 40), November 12, 1958, p. 18.

27. *New York Times*, October 1, 1958, and *The Times* (London), October 1, 1958.

28. Lin Piao, "Hold High the Red Banner of the Party's General Line and Chairman Mao Tse-tung's Military Thought and Advance in Big Strides," *NCNA*, September 29, 1959; *Current Background* (No. 596), October 7, 1959, p. 7.

29. John L. Steele, *Life*, July 13, 1959, p. 36. Such rockets are probably short-range ones rather than long-range missiles but even short-range rockets could probably reach most targets in East Asia. Peking also has IL-28 bombers capable of carrying atomic bombs.

30. *Christian Science Monitor*, June 25, 1959.

31. *New York Times*, September 18, 1959.

32. *New York Times*, February 20, 1960.

33. *New York Times*, January 11, 1960. The expert mentioned was Dr. Chien Hsüeh-shen, formerly professor of jet propulsion at California Institute of Technology.

34. *U.S. News and World Report*, January 11, 1960, pp. 47–48.

35. Fred Greene, "Military Bases and Programs of Communist China," p. 4

(typescript, unpublished, prepared for the Senate Disarmament Subcommittee by the Legislative Reference Service, Library of Congress, March 22, 1957), cited in *Disarmament and Security in Eastern and Southern Asia* (see note 66), p. 9.

36. W. Davidon, M. Kalkstein, and C. Hohenemser, *The Nth Country Problem and Arms Control* (Washington, D.C.: National Planning Association, Planning Pamphlet No. 108, January 1960), pp. 27–28, lists Communist China as one of twelve countries, including France, "able to embark on a successful nuclear weapons program in the near future." This study estimates that "a typical weapons program for the manufacture of a few bombs per year" would require about five years to get into operation; see p. 21.

37. Modelski, *op. cit.*, p. 125.

38. Ch'ien, *op. cit.*, p. 12.

39. Modelski, *op. cit.*, p. 192.

40. Ch'ien, *op. cit.*, p. 12. In April 1960, Chou En-lai was reported to have told a Burmese official that Communist China expects to build atomic submarines within five years (*New York Times*, April 17, 1960).

41. Ch'ien, *op. cit.*, p. 14.

42. The data and analysis here are based on a personal communication from Arnold Kramish (RAND Corporation).

43. *Ibid.*

44. Modelski, *op. cit.*, p. 47, and information provided by Arnold Kramish.

45. *NCNA*, April 21, 1956, and *Wang Po*, September 10, 1956, in Modelski, *op. cit.*, p. 193.

46. Ch'ien, *op. cit.*, p. 18.

47. *NCNA*, January 28, 1959; *SCMP* 1948, February 4, 1959, pp. 2–7.

48. *Current Digest of the Soviet Press* (Vol. 11, No. 39), October 28, 1959, p. 22.

49. *New York Times*, April 3, 1960.

50. *Arbeiderbladet* (Oslo), February 15, 1960.

51. *New York Times*, April 9, 1960.

52. Mao Tse-tung, *Selected Works* (New York: International Publishers, 1954), I, 75.

53. See *Disarmament and Foreign Policy*, Hearings, Subcommittee on Disarmament, Committee on Foreign Relations, U.S. Senate, 86th Congress, 1st Session (Washington, D.C.: United States Government Printing Office, 1959), Part 1, pp. 4, 196.

54. Curiously enough, by far the largest detonations of conventional explosives anywhere in the world have been in Communist China. In 1956 several "immense explosions" took place in northwest China; they were reported to have been nonnuclear blasts detonated by a Soviet technical group. Their magnitude was as follows: July 19, 1.6 kilotons; November 15, 4.0 kilotons; December 31, 9.2 kilotons. Up to 1958, the largest nonatomic explosion ever detonated in the West was 1.3 kilotons. See Arnold Kramish, *Atomic Energy in the Soviet Union* (Stanford: Stanford University Press, 1959), p. 137. Speculating, it is conceivable that during this period, the Sino-Soviet partners were able to test the problems of detecting, and perhaps concealing, large blasts in that remote area of China.

55. *Control and Reduction of Armaments,* Hearings, Subcommittee on Disarmament, Committee on Foreign Relations, U.S. Senate, 84th Congress, 2nd Session (Washington, D.C.: United States Government Printing Office, 1956), Part 2, pp. 75–77.

56. *Secretary Dulles' News Conference of July 2, 1957,* Department of State Press Release No. 405, July 2, 1957, pp. 5–6.

57. *Secretary Dulles' News Conference of June 10, 1958,* Department of State Press Release No. 319, June 10, 1958, pp. 2, 9.

58. *Disarmament and Foreign Policy, op. cit.,* Part 2, p. 379.

59. *Text of Remarks by the Honorable Christian A. Herter,* Department of State Press Release No. 667, September 23, 1959, p. 7.

60. *Statement Issued by Lincoln White,* Department of State, January 21, 1960.

61. *Secretary Herter's News Conference of February 8, 1960,* Department of State Press Release No. 53, February 8, 1960, pp. 3–4, 7.

62. *New York Times,* January 20, 1960. Later, in April, Chou En-lai said: "An international agreement made without the participation and signature of China's representatives will have no binding force whatsoever on China" (*New York Times,* April 11, 1960).

63. George Kennan, *Disarmament and Foreign Policy, op. cit.,* Part 2, p. 204.

64. For further elaboration, see A. D. Barnett, *Communist China and Asia, Challenge to American Policy* (New York: Harper and Brothers, 1960), esp. chaps. 13–15.

65. *Ibid.,* chap. 6.

66. See *Disarmament and Security in Eastern and Southern Asia,* Staff Study No. 9, Subcommittee on Disarmament, Committee on Foreign Relations, 85th Congress, 1st Session (Washington, D.C.: United States Government Printing Office, July 1957), pp. 15–23, and *Disarmament and Foreign Policy, op. cit.,* Part 2, pp. 364–368.

15. The Role of the Smaller Powers

PAUL M. DOTY

1. The National Planning Association, *Pamphlet No. 108* (Washington, D.C.: NPA, 1959); also, Howard Simons, "World-wide Capabilities for Production and Control of Nuclear Weapons," *Dædalus, 88*: 385–409.

2. P. M. S. Blackett, "Thoughts on British Defence Policy," *The New Statesman* (1959), *58*:783.

3. George R. Kennan, *Russia, the Atom and the West* (New York: Oxford University Press, 1958).

4. Major-General John B. Medaris, in the *New York Times,* April 21, 1960.

5. The consequences of research and development in weapons systems are difficult to predict, hence such recommendations require some caution. In the case of agents of chemical warfare, their further development and deployment by the smaller powers could stimulate the major powers to a greatly expanded effort in this area, resulting perhaps in a breakthrough to a different lead in efficiency. This would have unpredictable effects. However, the possibility of a

substantial breakthrough in chemicals seems unlikely, since effectiveness as based on weight appears to be approaching a limit. To increase the yield, therefore, one can depend only on increasing the efficiency of dispersal at the target.

6. A discussion of many specific roles that the smaller powers could play cannot be included here since they depend on particular disarmament plans which are beyond the scope of this article.

16. Inspection Techniques of Arms Control

BERNARD T. FELD

1. Herman Kahn, "The Arms Race and Some of Its Hazards," in this volume.

2. Jerome B. Wiesner, "Comprehensive Arms-Limitation Systems," in this volume.

3. Letter of instruction to Fredrick M. Eaton, United States Representative at the Ten-Nations Geneva Disarmament Conference, the *New York Times,* March 13, 1960.

4. Speech before the United Nations General Assembly, the *New York Times,* September 19, 1959.

5. Speech before the United Nations General Assembly, the *New York Times,* September 18, 1959.

6. Speech before the British Parliament, the *New York Times,* April 8, 1960.

7. Western Five-Nation Proposal for General Disarmament, the *New York Times,* March 15, 1960.

8. United States Department of State, *Disarmament: The Intensified Effort* (Publication 6676), July 1958.

9. United States Senate Subcommittee on Disarmament, *Hearings and Reports on the Control and Reduction of Armaments* (Washington, D.C.: 1956–1959).

10. Seymour Melman (ed.), *Inspection for Disarmament* (New York: Columbia University Press, 1958).

11. *Report of the Conference of Experts to Study the Possibility of Detecting Violations of a Possible Agreement on the Suspension of Nuclear (Weapon) Tests* (United Nations Document A/3897, New York, 28 August 1958).

12. Lloyd V. Berkner *et al., The Need for Fundamental Research in Seismology:* Report of the Panel on Seismic Improvement (Washington, D.C.: Department of State, July 1959).

13. Leo Szilard, "To Stop or Not to Stop," *Bulletin of the Atomic Scientists* (March 1960), *16*: 82.

14. B. T. Feld, D. G. Brennan, D. H. Frisch, G. L. Quinn, and R. S. Rochlin, *The Technical Problems of Arms Control,* Program of Research No. 1 (New York: Institute for International Order, May 1960).

15. United States Department of State, *A Report on the International Control of Atomic Energy* (the Acheson-Lilienthal Report), Publication 2398 (Washington, D.C.: March 14, 1946).

16. United States Department of State, *United States Atomic Energy Proposals* (as presented by B. M. Baruch to the United Nations Atomic Energy Commission, June 14, 1946), Publication 2460 (Washington, D.C.).

17. The Polish proposal, submitted to the United Nations General Assembly on October 2, 1957, the *New York Times,* February 18, 1958.

18. *Report of the Conference of Experts* (Held from November 10, to December 18, 1958, in Geneva) *for the Study of Possible Measures Which Might Be Helpful in Preventing Surprise Attack* (United Nations Document A/4078, New York, 5 January 1959).

19. Thomas C. Schelling, "Reciprocal Measures for Arms Stabilization," in this volume.

20. Leo Szilard, "How to Live with the Bomb and Survive," *Bulletin of the Atomic Scientists* (February 1960), *16*:58.

21. United States Department of State, *International Control and Prohibition of Atomic Weapons,* Recommendations of the United Nations Atomic Energy Commission, Publication 3646 (Washington, D.C.: October 1949).

22. Donald G. Brennan, "Why Outer Space Control," *Bulletin of the Atomic Scientists* (May 1959), *15*: 198.

23. Lewis C. Bohn, unpublished memorandum, January 12, 1956; Bohn called this "psychological inspection."

24. William C. Davidson, Marvin I. Kalkstein, and Christoph Hohenemser, *The Nth Country Problem: A World Wide Survey of Nuclear Weapons Capability,* National Planning Association, Planning Pamphlet No. 108 (Washington, D.C.: January 1960).

25. Paul M. Doty, "The Role of the Smaller Powers," in this volume.

26. Richard L. Kirk, Testimony on May 14, 1957, in the *Hearings on the Statute of the IAEA,* United States Senate, Committee on Foreign Relations (Washington, D.C.: United States Government Printing Office, 1957).

27. United States House of Representatives, *Research in Chemical, Biological and Radiological Warfare,* Report No. 815, August 10, 1959.

28. *Proceedings of International Pugwash Conference of Scientists on Biological and Chemical Warfare,* The Terminal Tower, Cleveland, Ohio, August 24, 1959.

17. Public Opinion and the Control of Armaments

ITHIEL DE SOLA POOL

1. For a discussion of the character and consequences of mediated experience, see Daniel Lerner, *The Passing of Traditional Society* (Glencoe, Ill.: The Free Press, 1958).

2. E. Kris and N. C. Leites, "Trends in 20th-Century Propaganda," in Geza Roheim (ed.), *Psychoanalysis and the Social Sciences* (New York: International Universities Press, 1947), vol. I.

3. See John R. Thomas, *Report on Service with the American Exhibition in Moscow* (RAND Corporation Report P-1859), March 15, 1960.

4. Alex Inkeles and Raymond A. Bauer, *The Soviet Citizen* (Cambridge: Harvard University Press, 1959), chap. 7.

5. Inkeles and Bauer, *op. cit.*

19. Adjudication and Enforcement in Arms Control

LOUIS B. SOHN

1. *United Nations Treaty Series, 298*: 11–165.

2. See, e.g., Louis M. Bloomfield, *Boundary Waters Problems of Canada and the United States: The International Joint Commission, 1912–1958* (Toronto: Carswell, 1958).

3. Manley O. Hudson, *International Tribunals: Past and Future* (Washington, D.C.: Carnegie Endowment for International Peace, 1944), pp. 32–47.

4. "Report of the International Law Commission Covering the Work of Its Tenth Session, 28 April–4 July 1958," United Nations General Assembly, *Official Records,* 13th Session, Supplement No. 9, pp. 5–8.

5. International Court of Justice, *Yearbook, 1958–1959* (The Hague: 1959), p. 13.

6. *United Nations Treaty Series, 261*: 165–173, 247–267; *298*: 271–272.

7. *Ibid., 298:* 197–200, 212–217.

8. International Atomic Energy Agency, *Multilateral Agreements.* Legal Series, No. 1, pp. 192–193, 197–200 (Vienna: 1959).

9. Manley O. Hudson, *International Legislation* (Washington, D.C.: Carnegie Endowment for International Peace, 1936), V (1929–1931), 436–444.

10. Manley O. Hudson, *World Court Reports* (Washington, D.C.: Carnegie Endowment for International Peace, 1938), III, 326–327.

11. See references 6 and 7.

12. *United Nations Treaty Series, 261*: 225–227.

21. Government Organization for Arms Control

HUBERT H. HUMPHREY

1. United States Senate. Senate Foreign Relations Subcommittee on Disarmament, Hearings on the Control and Reduction of Armaments, Part 1, January 25, 1956, p. 12.

2. The four conferences referred to are: (1) the Conference of Experts to Study the Methods of Detecting Violations of a Possible Agreement on the Suspension of Nuclear Tests, held from July 1, 1958, to August 20, 1958; (2) the Conference of Experts for the Study of Possible Measures Which Might Be Helpful in Preventing Surprise Attack, held from November 10, 1958, to December 18, 1958; (3) Conference on the Discontinuance of Nuclear Weapons Tests, convened October 31, 1958, and still in session; and (4) Conference of the Ten-Nation Committee on Disarmament, held from March 15, 1960, to June 27, 1960.

3. See the testimony of President's Disarmament Assistant quoted on p. 393.

4. In a major speech on disarmament on October 13, 1959, before the United Nations General Assembly, United States Ambassador Henry Cabot Lodge said of the Coolidge appointment: "As for the United States, President Eisenhower has recently set in motion a new and thorough review of disarmament in the light of present-day technology. This review will prepare us to participate fully and constructively in the deliberations scheduled for next year."

5. United States Senate. Senate Government Operations Subcommittee on National Policy Machinery, Hearings, April 26, 1960.

6. The Senate does not have the option of substantially altering the language of a treaty without running the risk of subjecting it to complete renegotiation.

Foreign Comment

1. Camille Rougeron, *Science et Vie* (July 1960).

2. *The Reporter,* September 5, 1960.

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